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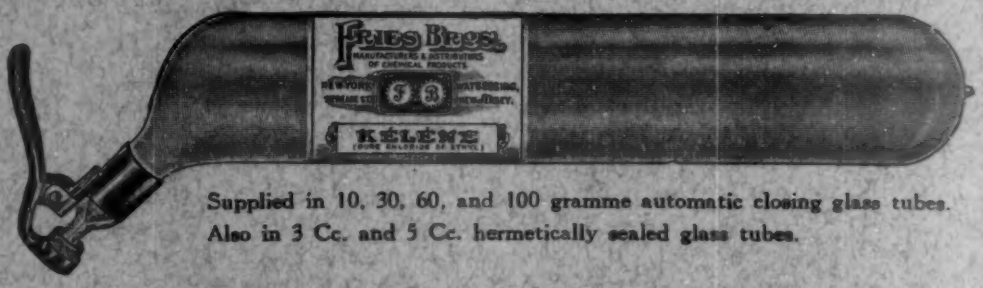

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ANNALS *of* SURGERY

Vol. XCI JUNE, 1930 No. 6

COAGULATION OF BLOOD

I. THE COMPARATIVE VALUES OF CALCIUM AND GLUCOSE AS AGENTS FOR DECREASING THE CLOTTING TIME*

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THE hæmorrhage which sometimes occurs after the release of an obstruction of the common bile duct is not as yet definitely understood. Although hæmorrhage is not of as frequent occurrence as it once was, it still is seen often enough to be a complication which is looked upon with considerable dread.

Sufficient work has already been done on the clotting and bleeding time of the blood of patients who have icterus to permit of certain definite deductions. A number of these patients, jaundiced for long or short periods of time, exhibit no evidences of an increase in the time for the clotting of shed blood. Another group have alterations of the clotting time so that shed blood does not coagulate in the normal period of time as estimated by one method or another. However, patients with a prolonged clotting time are not necessarily the ones who bleed after operation. Bancroft, Kugelmass and Stanley-Brown [1] have concluded that the coagulation and bleeding time are of very little value in determining a hæmorrhagic tendency. They have determined from a study of a number of factors, the coagulation index. Their study is an important one and emphasizes the fact that the coagulation time is not a prognostic index to be depended upon. It has also been our experience that a return to a normal coagulation time after treatment is not sufficient evidence that post-operative oozing will not occur.

Pre-operative treatment of the jaundiced patient by a variety of methods has been employed to prevent post-operative hæmorrhage. Such treatment will in many instances cause a reduction in the coagulation time with a return to values well within normal limits. It frequently happens that when two or more substances are used in the preparation or treatment of patients suffering from a disease, we empirically attribute beneficial results to the drug which most likely might have been supposed to bring about those results. This may not in any way be supported by either prolonged clinical observation or by experimental fact. It may happen that several interrelated factors act favorably to bring about the desired result or that one factor in itself might have brought it about if used alone. Such information can only be obtained by careful clinical and laboratory analysis.

* Read before the conjoint meeting of the Philadelphia Academy of Surgery and the New York Surgical Society, February 13, 1930.

Since Whipple [2] and Walters,[3] independently, suggested the use of calcium solutions in the pre-operative preparation of jaundiced patients, it has been customary to use a solution of calcium salts intravenously, before operation, in the majority of clinics in this country. Previous to their work, Mayo-Robson had suggested that calcium salts would be helpful in restoring a disturbed calcium balance in the jaundiced patient. Because calcium is known to play some part in coagulation, its use has become widespread even though, with one exception, no one has demonstrated a calcium deficiency in obstructive jaundice in the clinical patient.

Simultaneous with the widespread use of calcium solutions in these cases, surgeons began using solutions of glucose, to increase the hepatic glycogen reserve and thus improve the hepatic function. It has been known that certain liver degenerations give rise to a condition where clotting of shed blood is delayed. Since glucose causes rapid liver repair, it might be supposed that improvement of liver function, after its use, would reflect itself in a number of ways.

For many reasons it seemed worthwhile to ascertain whether or not calcium was necessary to reduce the clotting time in patients suffering from obstructive jaundice. If calcium was not necessary, to what factor might we attribute the reduction of the coagulation time, which has been observed clinically after preparation of the jaundiced patient, when an abnormal increase existed, and what factor or factors were responsible for a reduction in the number of post-operative hæmorrhages in jaundiced patients?

We have therefore studied the effect of calcium and glucose on the coagulation time of the normal and jaundiced dog and of the jaundiced patient. Besides these we have observed the effect of a few other salts and sugars. We are reporting here only the results of the use of calcium and glucose.

The coagulation time was determined in all experiments by the Lee-White [4] method. After experience with a variety of methods we believe that this procedure gives more uniform results than any other we have tried. The blood samples from the dogs have been taken in most instances by arterial puncture so as to avoid trauma and the application of a tourniquet during withdrawal of the blood. We know that even this method is by no means quantitative and have taken the rather arbitrary point of 25 per cent. reduction in the clotting time as definite evidence that one or another of the substances used had a beneficial action.

The Effect of Calcium on Liver Degeneration.—Minot and Cutler [5] have recently reported that calcium salts exerted a highly protective action in preventing and treating the increase in guanidine and guanidine-like substances in the blood of dogs suffering from liver degeneration following the administration of chloroform and carbon tetrachloride. Although no definite relationship between the increase in guanidine and hepatic damage has been established, they believe that the liver damage probably accounts for the abnormal blood guanidine.

Partos and Svec [6] report that the intravenous injection of calcium chloride

causes a hyperglycæmia, but we cannot agree that this is a consistent finding. On the other hand, one of us (C. R.) has recently obtained data which would lead us to believe that the prolonged administration of calcium exerts a beneficial action in the liver damage of ductal obstruction. However, the administration of calcium was continued for a much longer period than has been heretofore reported in clinical practice.

Calcium and Blood Coagulation.—The literature on this subject has been covered by Wangensteen [7] in an excellent article published in this journal. Much of the work that has been done is of little value since the methods used for estimating the coagulation time were open to too many errors.

In a study on calcification made several years ago by one of us (I. S. R.) with M. E. Morrison, we were able to study a series of dogs who had serum calcium values of from 4 to 8 milligrams per 100 cubic centimetres. These animals exhibited no evidences of an increase in the coagulation time. We were fortunate in being able to study the coagulation time of a patient who had parathyroid tetany following the accidental removal of parathyroid glands during thyroidectomy. This patient, with a serum calcium of 4.6 milligrams per 100 cubic centimetres, had a normal coagulation time. Similar results have been reported by Simpson and Rasmussen,[8] while Kottman and Lidsky [9] reported a decrease in the coagulation time in parathyroidectomized dogs.

A study of the coagulation time of the blood in two dogs whose serum calcium values had been elevated after the administration of activated ergosterol and parathormone respectively was made. The dogs' serum calcium values were 20 and 26 milligrams per 100 cubic centimetres respectively. In both of these, the coagulation time was high normal or above normal for the method used; 9.18 and 12.5 minutes respectively. Our data do not agree with the results obtained by Gordon and Cantarow,[10] and Cantarow, Dodek and Gordon,[11] who found that parathormone (Collip's Extract) given to normal and jaundiced patients caused a consistent reduction in the coagulation time.

The study of the serum calcium of over twenty-five jaundiced patients and a large series of adult dogs with experimental jaundice has never disclosed any appreciable reduction from normal values. One patient had a serum calcium of 8.8 milligrams per 100 cubic centimetres while the dogs have all been within normal limits. Snell, Greene and Rowntree [12] and numerous other observers have obtained similar results. Buchbinder and Kern [13] have been the only investigators who have reported a progressive decrease in serum calcium in experimental jaundice. They used young puppies. They also reported three patients with jaundice who had low serum calcium values which returned to normal with a decrease of the jaundice. The results of these workers stand alone in a wealth of evidence.

A number of papers have appeared which have attempted to differentiate the rôles of ionizable and non-ionizable calcium in the clotting process. Vines,[14] who studied this aspect of the subject, came to the conclusion that

ionized calcium is not necessary in the clotting process. The addition of oxalate, citrate or fluoride to normal blood in amounts chemically equivalent to the total calcium of the blood does not inhibit coagulation. Vines believed that the above anti-coagulants all inhibited clotting primarily, by combining with a calcium-containing complex; the amount of anticoagulant required to neutralize the action of the complex was in each case in excess of the chemical equivalent of the calcium attached to it.

Stewart and Percival [15] studied the delay in coagulation of ox blood after mixing it with varying amounts of anticoagulants, citrate, oxalate, fluoride, etc. They decided that ionizable calcium had nothing to do with coagulation; if anything, it lengthened the coagulation time. They, however, did believe that a complex protein-calcium compound, the identity of which they did not determine, played a definite part in the clotting process.

We have studied the effect of calcium chloride and calcium gluconate (Sandoz) on the coagulation time of the blood in normal and jaundiced dogs. The calcium was given to some dogs on successive days as it is given in the preparation of the jaundiced patient; in others, the coagulation time was determined after a single injection.

TABLE I

Effect of Repeated Administration of Calcium Gluconate After Cholecystectomy and Ligation of Common Duct

Number of dog	Normal coagulation time in minutes	Operation	Coagulation time in minutes	Van den Bergh (units)	Calcium gluconate 10 c.c. 10 per cent	Coagulation time on following day
					Days after operation	
432	4.8	22	4.1	16.5	22–23–24	4.8
405	7.7	8	5.5	12.0	24–25–26 27–28	6.0

In Table I are given the results obtained after repeated subcutaneous injections of calcium gluconate to two dogs who had the gall-bladder removed and the common duct ligated.

In Table II we include the results obtained in six normal dogs after a single intravenous injection of calcium chloride or calcium gluconate.

These experiments fail to demonstrate the value of calcium in causing a consistent reduction of the coagulation time in the normal dog. In only one instance was a 25 per cent. reduction in the coagulation time noted. This was in dog No. 519 where the maximum reduction was 42 per cent. after a single injection of calcium.

The Use of Glucose in Liver Degeneration.—Schreiber,[16] in 1913, and Kehr,[17] a year later, suggested the use of glucose previous to operation on jaundiced patients. Its use became widespread in this country after 1920. Walters advocated the administration of glucose in conjunction with calcium chloride. There can be little doubt that the administration of glucose has

been a major factor in the reduction of the surgical mortality attending operative procedures for obstructions of the common duct.

Davis, Hall, and Whipple [18] have shown that a high carbohydrate diet will cause liver regeneration at the rate of 100 grams a day, in the degeneration following chloroform. We have shown that following the release of ductal obstructions a carbohydrate diet will result in a more rapid return to normal histologic structure than any other diet. Even when ductal obstruction exists, we believe that the administration of glucose exerts a beneficial effect although the liver cannot deposit glycogen in normal amounts.

Liver degeneration occurring as the result of chloroform or phosphorus

TABLE II

Effect of Single Injections of Calcium Salts

Number of dog	Normal coagulation time in minutes	Days after operation	Injection	Coagulation time 15 minutes after injection	Coagulation time 1 hour after injection
519	6.3	11	10 c.c. cal. gluc.	5.4	3.6
199	7.0	None	10 c.c. cal. gluc.	7.9	6.8
461	5.7	None	10 c.c. cal. gluc.	6.2	5.2
512	5.8	None	10 c.c. cal. gluc.	4.5	4.9
515	4.4	None	10 c.c. cal. gluc.	5.0	4.6
786	7.3	None	10 c.c. $CaCl_2$	5.8	7.7

poisoning frequently is associated with an increase in the coagulation time. An increase in the clotting time may or may not be associated with the degeneration which occurs after obstruction of the common duct. In our experience, the clinical cases which have prolonged clotting times have also severe liver damage. The exact cause of the increase in the coagulation time after liver degeneration is not definitely understood. McMaster and Drury [19] have shown that, at least in the rabbit, the liver is the sole source of blood fibrinogen. Mann, Bollman and Markowitz [20] have, on the other hand, found that the coagulation time of the blood following complete removal of the liver is variable. In some animals it remained normal for twenty-four hours after hepatectomy. In others, it was delayed immediately after operation but was normal at later periods; while in still others there was a progressive increase in the coagulation time up to failure of coagulation. They believe that the delay in coagulation time of the blood in their animals was due to deficiencies in the blood fibrinogen although they state that a simple relation-

ship does not appear between fibrinogen content and coagulation time. This latter observation we have confirmed in normal and jaundiced dogs.

It is interesting to note here that in Minot and Cutler's experiments, which we reviewed under the discussion on calcium therapy, the increase in blood guanidine observed in their dogs was soon followed by a marked fall in the blood sugar which at times reached levels of marked hypoglycæmia. Ellis [21] has found that glucose acts protectively in presenting the toxæmia resulting from the injection of guanidine. Furthermore, both observers found that the injection of guanidine resulted in hypoglycæmia. Such observations add further evidence to the protective action of glucose in hepatic disease.

We might reasonably say that as far as information is now available, intravenous glucose gives better results in the various types of liver degeneration than any other substance so far used. It seems reasonable to suppose that the less liver damage existing, the less will be the danger of hæmorrhage.

The Effect of Glucose on the Coagulation Time of the Blood.—Experimental evidence has been advanced which indicates that with an increase in the blood sugar there is a decrease in the coagulation time. Partos and Svec in 1927 reported an exact parallelism between the coagulation time and the blood sugar content. In effect they found that substances which reduced the coagulation time caused hyperglycæmia by mobilizing glycogen while those substances which increased the coagulation time decreased the blood sugar. Cannon and Gray [22] have found that an increased output of adrenalin, which causes a hyperglycæmia, resulted in a decrease in the coagulation time. Rabinowitch [23] observed a decrease in the coagulation time following inhalation anæsthesia. The maximum reduction occurred within the first fifteen minutes after induction of the anæsthesia. Anæsthesia also causes hyperglycæmia.

Boldyreff,[24] in an article entitled "The Pancreatic Triad," came to opposite conclusions. He states that the hyperglycæmia which he found associated with "a complete loss of pancreatic fluid either by pancreatectomy or fistula produces (1) a rise in the percentage of blood sugar, and (2) a decrease of the blood coagulability." Turcatti,[25] using a similar procedure, obtained results similar, but not so consistent as those of Boldyreff. He does not report the method which he used for determining coagulation time. The figures given by him are very short and a doubt exists in our minds as to the accuracy of the method used.

It has been our experience that although a reduction of the coagulation time is frequently associated with an increase in the blood sugar, the two do not consistently parallel each other. We have studied the effect of glucose given intravenously and by mouth on the normal and jaundiced dog and on the jaundiced patient. We have furthermore estimated the effect of glucose on the jaundiced dog after the animal had received calcium gluconate (Sandoz) for several days previous to the administration of glucose.

Table III shows the effect of glucose on a group of normal animals.

Twenty-one estimations were made. In 86 per cent. of the injections a reduction of the coagulation time of 25 per cent. or more was obtained. In 38 per cent. the reduction was from 25 to 50 per cent.; in 48 per cent. it was

TABLE III

Effect of Glucose Administration to Normal Dogs

Number of dog	Normal coagulation time in minutes	Gms. of glucose intravenously	Coagulation time 15 minutes later	Coagulation time 1 hour later	Coagulation time 2 hours later	Coagulation time 3 hours later	Coagulation time 4 hours later	Coagulation time 6 hours later
841	6.1	37.0	3.3				4.6	
65	5.5	22.0	4.0	4.1	3.1			
844	5.9	34.0	4.6	4.5				
831	9.4	23.0	3.9		3.6			
85	5.9	24.0	4.3		3.9			
761	5.1	17.0	3.4		2.7			
30	3.9	30.0	2.7		2.9		3.2	
30 A	6.4	16.5	4.9					
30 B	7.9	30.0	4.1	3.7				
712	6.4	16.5	4.9		3.0			
17	6.1	22.5	4.6		4.7		3.4	
30 C	3.8	10.0	1.8					
513	9.1	27.0	5.6					
733	4.1	18.0	3.2					
690	5.1	18.5	2.9	3.8				
642	7.8	25.0	6.5					
773	5.8	21.0	2.0					
833	9.7	32.0	5.8		6.1			
199	6.3	10.0	5.2	2.7				
199 B	7.5	10.0	2.1					
71	10.2	21.0	4.9				6.2	

more than 50 per cent. There were 14 per cent. of failures. This is in marked contrast to the results obtained from normal dogs after the administration of calcium salts where only 16.6 per cent. of positive results were obtained.

TABLE IV

Effect of Glucose Given to Jaundiced Animals

Number of dog	Normal coagulation time in minutes	Gms. of glucose intravenously	Coagulation time 15 minutes later	Coagulation time 1 hour later	Coagulation time 2 hours later	Coagulation time 3 hours later	Coagulation time 4 hours later	Coagulation time 6 hours later
27	12.1	20.0	4.5		5.5			
432	4.1	50.0 *	4.2	2.2	3.5			
411	7.5	23.5	4.5		5.2			
405 A	5.4	50.0 *	5.7	4.31	3.5			
405 B	8.4	50.0 *	8.4	5.26	2.1			

* Glucose given by stomach tube.

Table IV gives the results obtained following the administration of glucose to animals with experimental obstruction of the biliary passages. In two instances, the glucose was given intravenously while in three it was given by stomach tube. In the later instances, it will be seen that the maxi-

TABLE V

Calcium and Glucose

Number of dog	Normal sugar in mg.	Normal coagulation in minutes	Ca. gluc. subcutaneously	Coagulation time 24 hours after last Ca. injection	Gms. glucose by stomach tube	Blood sugar 15 minutes later in mg.	Coagulation time 15 minutes later	Blood sugar 45 minutes later	Coagulation time 45 minutes later	Blood sugar 1 hour, 15 minutes later	Coagulation time 1 hour, 15 minutes later	Blood sugar 2 hours later	Coagulation time 2 hours later
432	75	4.8	3 daily injections, 20 c.c. of 10%	4.8	50.0	141	4.7	176	4.5	198	1.6	207	1.7
405	81	7.7	5 daily injections	6.0	50.0	158	4.2	198	5.8	192	2.4	194	3.8

mum reduction of the coagulation time occurs later than in the former. Every animal gave positive results. In 40 per cent. a reduction of 25 to 50 per cent. was obtained while in 60 per cent. a reduction of 50 per cent. or more was obtained.

Two jaundiced dogs were studied before and after repeated injections of calcium gluconate (Sandoz) similar to the method used for preparing jaundiced patients for operation. Table V gives the coagulation time before the administration of calcium; twenty-four hours after the last injection; and the coagulation time in the same animals subsequent to the administration of glucose by stomach tube. The calcium had practically no effect on the coagulation time while glucose caused a reduction of 60 and 69 per cent. respectively.

In two dogs we studied the effect of the intravenous injection of glucose after hepatectomy. Table VI gives the normal coagulation time; the coagulation time fifteen minutes after the completion of the final stage of the hepatectomy; and again two hours later. These animals had a rise in the coagulation time of 38 and 48 per cent. respectively.

TABLE VI

Hepatectomy and Glucose

Number of dog	Normal coagulation time in minutes	Hepatectomy	Coagulation time 15 minutes later	Glucose continuously	Coagulation time 2 hours after hepatectomy
111	10.5	Hepatectomy	9.1	43 gm.	14.0
713	8.6	Hepatectomy	7.9	53 gm.	12.8

It seemed possible that glucose might act by stimulating the formation of fibrinogen. A careful study of the blood fibrinogen in normal and jaundiced animals before and after the administration of glucose has thrown no light on the mechanism by which glucose acts. We have not found any definite increase in the blood fibrinogen associated with the decrease in the coagulation time after glucose administration.

The results obtained following the intravenous administration of glucose to six jaundiced patients is interesting. They are given in Table VII. The first case was one of advanced liver damage who died eight hours after admission. Glucose was without effect. We are indebted to Dr. G. P. Muller for permission to study her, as well as the second and third cases. The last patient had a carcinoma of the bile ducts. Here also glucose was without effect, while calcium did cause a very slight reduction of the coagulation time. Dr. E. L. Eliason, who kindly gave us permission to study this patient, reported a very seriously damaged liver. Whether the calcium alone was the factor causing a reduction in the coagulation time or not we cannot definitely state, but it would appear that this was the case.

Summary and Conclusions.—It would seem that except in very rare instances ionized calcium does not favorably affect the coagulation time of the blood of normal or jaundiced dogs. Glucose, on the other hand, given by

mouth or intravenously does favorably affect the coagulation time in both types of animals in the majority of instances. Glucose causes a reduction in the coagulation time in patients with obstructive jaundice when the liver damage is not beyond the stage of partial repair. Glucose has no effect on

TABLE VII

Effect of Glucose Administered to Jaundiced Patients

Name	Van den Bergh (units)	Coagulation time before glucose	Glucose intravenously	Coagulation time immediately after	Coagulation time 1 hour later	Coagulation time 2 hours later	Coagulation time 3 hours later
Mrs. M.	33.0	25.0	100 gm.	20.3		28.0	
Mrs. S. M.	11.0	13.3	100 gm.	3.8			
Mrs. I. T.	16.0	6.8	90 gm.	4.5			
Mrs. H.	11.0	10.9	100 gm.	3.0		3.6	
Miss E. N.	18.5	7.5	100 gm.	4.5		3.2	
Mr. E. C.	20.0	70.6	110 gm.	55.2	79.5 *	51.0 †	25.2 ‡

* Calcium chloride 10 c.c. 10 per cent. intravenously.
† Twenty minutes after calcium.
‡ Thirty minutes after calcium.

the coagulation time after hepatectomy. Given to both the normal and jaundiced dog, glucose causes no increase in the blood fibrinogen.

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BONE METASTASES IN CANCER OF THE BREAST*

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In the six-year period from 1924 to 1929 inclusive 267 patients with breast cancer were registered in the Radiological Department of the Philadelphia General Hospital. The great majority of these patients were in the late stages of the disease—being inoperable or having recurrence after operation—and only a few came sufficiently early for radical operation. Many of the 267 succumbed from extensive visceral metastases before sufficient time elapsed to develop bone metastasis. In this group were two patients with typical inflammatory type of cancer of the lactating breast and they died in three and nine months respectively. Of this number 204 had more or less extensive X-ray examination of the skeleton by Dr. E. Burvill Holmes. Of the 204 röntgenographed, 101 (49.5 per cent.) gave definite evidence of bone metastases.

Of these 101 patients 100 were women and one a man. We now have under our care another man with cancer of the breast showing metastases to the bones of the shoulder girdle homolateral to the affected breast. The average duration of life as given in their histories from onset of symptoms to death in the eighty-six who have died is twenty-eight months. This average duration no doubt would have been much longer except for many of these patients being psychopathics or of such low intelligence that their own or their relatives' first recognition of the primary tumor was in the stage of beginning ulceration. In the fifteen with bone metastases alive on January 1, 1930, the average duration since the first onset of breast symptoms was ninety and six-tenths months.

There was no reasonable doubt as to the correctness of the clinical diagnosis of primary breast cancer in any of these late cases of bone metastases but microscopic confirmation was made at the original operation, usually at other hospitals, in thirty-four; by biopsy in six; and at autopsy in thirty-nine.

Of the 103 patients who did not show bone metastasis at the time they were röntgenographed twenty-seven were alive on January 1, 1930. It is probable some of them will develop bone lesions before death.

Bone metastases in our series of 101 cases were found in the skull in fourteen; cervical vertebræ in ten; thoracic vertebræ in forty-one; lumbar vertebræ in forty-four; pelvic bones in forty-five; femora in thirty-two; leg bones in seven; foot bones in four; shoulder girdle in fifty-four; forearm bones in six; bones of hand in four; and ribs in thirty-five. Involvement of

* Read before the joint meeting of the New York Surgical Society and the Philadelphia Academy of Surgery in Philadelphia, February 13, 1930.

cervical vertebræ was probably much more frequent than the figures indicate because skiagrams of cervical regions in many cases were inadequate to determine whether or not metastases were present. In several cases in which lateral views of the thoracic and lumbar spine were not taken there may also have been more vertebral involvement than we have indicated.

In all of the 101 cases the bone lesions were destructive in type but in two of them with negative Wassermann reactions there was associated osteosclerosis. The first effect of metastasis was to cause osteoporosis and then followed, possibly as a result of nature's efforts at repair, an osteoscleroFIG. 1.—Combined osteoporosis and osteosclerosis.

sis in the same region. The most distant areas of invasion all showed porosis and inside these distant areas sclerosis was the rule. (Fig. 1.) That the bone lesions in one of these two cases were cancerous was confirmed by microscopy of bone sections obtained at autopsy. These findings are similar to those usually encountered in bone metastases secondary to prostatic cancer as illustrated by the set of röntgenograms exhibited at the meeting but not reproduced in this printed article and also by röntgenograms of a case reported in an earlier paper.[1] The most common cause of bone metastases is mammary cancer in women and prostatic cancer in men.

The following two cases displayed the most extensive bone metastases—and Case I the most extensive skin nodules also—that we found in this series.

CASE I.—A white woman, seventy years of age, the mother of three children, was admitted to the Radiological Department of the Philadelphia General Hospital December 3, 1928. She gave a history of having had excised from her right breast in August, 1926, a nonulcerated lump which had been present for two years. The hospital at which the operation was performed reported the pre-operative diagnosis was "fibroma" and the post-operative microscopical diagnosis was "carcinoma simplex, scirrhous type." The patient received no further treatment of any kind and the family was not aware that the patient had cancer until three days before coming to us.

About four months after operation she first noticed small lumps in the skin overlying the chest. These nodules increased in number, being most marked over the torso front and back, but extending to the top of the head and downward to wrists and knees. She soon developed sharp stabbing pain in the back and shoulders which interfered with sleep but she was able to go about actively until one year ago when she

FIG 2.—Cutaneous nodules of face, arms and anterior chest and abdomen, due to lymphatic permeation.

FIG. 3.—Lymphatic permeation nodules of back and arm.

began having pain in region of right hip and swelling of right leg. She is now barely able to hobble around with the aid of a cane. She has had constant dribbling of urine for the past year.

Patient is emaciated. On inspection the most striking feature is a widespread distribution of cutaneous nodules. (Figs. 2 and 3.) They can be felt throughout the scalp; are particularly numerous around the angles of the jaws where they prevent opening of the mouth more than one centimetre. Nodules mechanically cause ptosis of upper lids which is complete on right and partial on left. Extensive coalescence of nodules over chest, abdomen and back presents an appearance somewhat resembling cancer en cuirasse. Over arms, forearms and thighs nodules are more distant one from another, extending down to the crease of each wrist, and in one hand two subcutaneous nodules are not seen but are easily palpable in the thenar eminence. Visible nodules extend bilaterally to the line of the knee-joint and palpable deeper nodules extend two inches below the knee on each side. Subcutaneous nodules are palpable throughout the area involved by skin nodules. The inguinal and saphenous lymph nodes are enlarged and indurated. Nodules quite similar to those on the skin are present in the mucosa of the mouth and vagina. Labia and adjacent skin are thickened and infiltrated. Digital

examination reveals induration of the lateral and anterior walls of the rectum. The right breast, which was the site of the original lesion, seems curiously free from evidence of cancer although its overlying skin is studded with nodules. Isolated nodules have reached the size of a silver half dollar. Their edges are raised above the surrounding skin but their centres are depressed by fibrous umbilication.

Mild pinching of skin or firm pressure anywhere causes severe distress. Examination of lungs not very satisfactory because of greatly lessed respiratory excursion due probably to extensive involvement and rigidity of overlying skin and subcutaneous tissues. Liver not demonstrably enlarged.

Röntgenograms of the entire skeleton reveal metastases in all the bones (Figs. 4 to 15) down to the ankles. The astragalus, os calcis, scaphoid and cuboid show early

FIG. 4.—Metastases in bones of cranium, face and upper cervical spine.

invasion in each foot. It is rare to find as extensive invasion of the hands as is shown in many of the terminal phalanges.

On the third day after admission the patient's family was informed she could not be cured and they took the patient home where she died five days later. No autopsy.

CASE II.—A fifty-six-year-old white mother of four children was admitted to the Radiological Service October 2, 1928. Her left breast was amputated for cancer March 21, 1916. In August, 1927, she began having pain in both hips extending down right leg to middle of tibia which caused her to limp for the past year. About August 1, 1928, while walking in her home, the right leg near its middle "bent under her." About four months before admission her physician stated she had a fracture of the right clavicle.

The patient was somewhat emaciated and her chief complaint was pain, mainly at back of neck and in right leg. On examination nothing very noteworthy found except

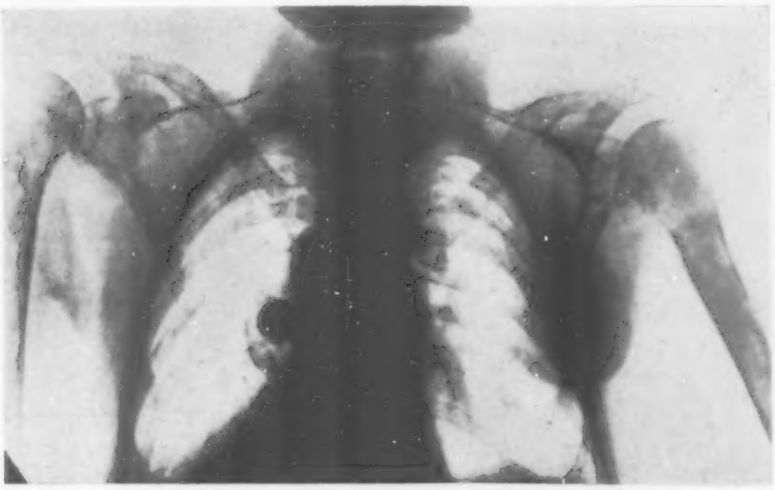

FIG. 5.—Metastases of all bones in röntgenogram.

FIG. 6.—Left humerus, radius and ulna.

FIG. 7.—Right humerus, radius and ulna.

FIG. 8.—Left hand.

FIG. 9.—Right hand, homolateral to affected breast and bones more extensively invaded than in left hand.

bilateral enlarged indurated supraclavicular and anterior and posterior cervical lymph nodes and the deformities of fractures of right clavicle and of both bones of right leg. No skin nor subcutaneous nodules. Examination of urine was negative. Blood count on Oct. 19, 1928, revealed 3,940,000 red cells, 7,400 white cells and 90 per cent. hæmoglobin—a very mild grade of anæmia in view of the extensive invasion of bone marrow. Differential count gave polymorphonuclears 72, lymphocytes 18, and mononuclears and transitionals 10. Wassermann was negative. Blood sugar was 100 and blood urea nitrogen 11.

Skiagrams are negative for pulmonary metastases but disclose involvement of

FIG. 10.—Lower chest and lumbar spine.

every bone other than those of the hands and feet (Figs. 16 to 28). In the right foot all the bones—even the terminal phalanges—are extensively invaded. In the left foot the os calcis and astragalus show very early invasion. In the hands some of the carpals, metacarpals and phalanges are very suspicious of early metastases. Fractures are shown in right tibia and fibula, right clavicle and several ribs. The röntgenogram of the spine (Fig. 17) was made on the autopsy table after removal of the sternum, adjacent ends of ribs, heart and lungs by a voltage of 30 k. w., an amperage of 5 milliamperes and flash exposure. It is interesting to note that in making röntgenograms far less exposure is required in the dead than in the living body. A spine picture in

FIG. 11.—Pelvis.

FIG. 12.—Left femur, tibia and fibula.

FIG. 13.—Right femur, tibia and fibula.

the living calls for a voltage of 70-127 k. w., an amperage of 20 milliamperes and an exposure of 12 seconds.

October 13, 1928, patient developed flaccid paralysis of both upper extremities and died October 21, 1928. Autopsy failed to reveal any gross evidence of cancer in the thoracic and abdominal cavities except in the lymph nodes along the abdominal aorta and iliac arteries. The photomicrograph in Fig. 29 illustrates permeation of lymphatics from vicinity of her abdominal aorta. A bone section from the lowermost end of left tibia (Fig. 28) revealed cancer by microscopical examination.

Correct interpretation of röntgenographic evidence is most important in the detection of early bone metastasis. Inexperienced radiologists frequently mistake early metastasis for atrophy of disuse or, especially in the

FIG. 14.—Early metastases in left tibia, fibula, astragalus, oscalcis and cuboid.

FIG. 15.—Early invasion in right tibia, astragalus, oscalcis, scaphoid and cuboid.

spine, for beginning osteoarthritis. The bone atrophy of disuse is fairly uniform whereas metastasis is uneven or spotty in distribution. Repetition of röntgenograms in two or three months and comparison with the original ones usually clear up any doubt. The interval between the first symptoms of breast cancer and the onset of bone invasion is extremely variable. Bone metastasis is always a late manifestation and about one-half the cases of uncured breast cancer die without developing X-ray evidence of bone changes.

In our cases of early bone invasion, aside from direct extension to ribs underlying the breast lesion, the order of frequency was the homolateral shoulder girdle, the third to sixth thoracic vertebræ, the upper lumbar vertebræ, the pelvic bones, and the lower cervical vertebræ.

The original röntgenograms supplemented by follow-up pictures at fre-

quent intervals in these early cases revealed many points of interest. Ordinarily it requires an interval of about two months between röntgenograms to note an appreciable progress in the metastatic lesions in bone. In one very exceptional case of rapid extension the first extensive X-ray study revealed metastases only in the homolateral shoulder girdle and one rib underlying the cancerous breast whereas only three months later metastases were found in the thoracic and lumbar spine, the pelvis and femora.

A frequent site of earliest bone invasion we find to be in the shoulder girdle homolateral to the breast cancer. In the earliest cases of shoulder girdle invasion we have seen, the head of the humerus and the glenoid process and adjacent region of the scapula were involved; at a slightly later

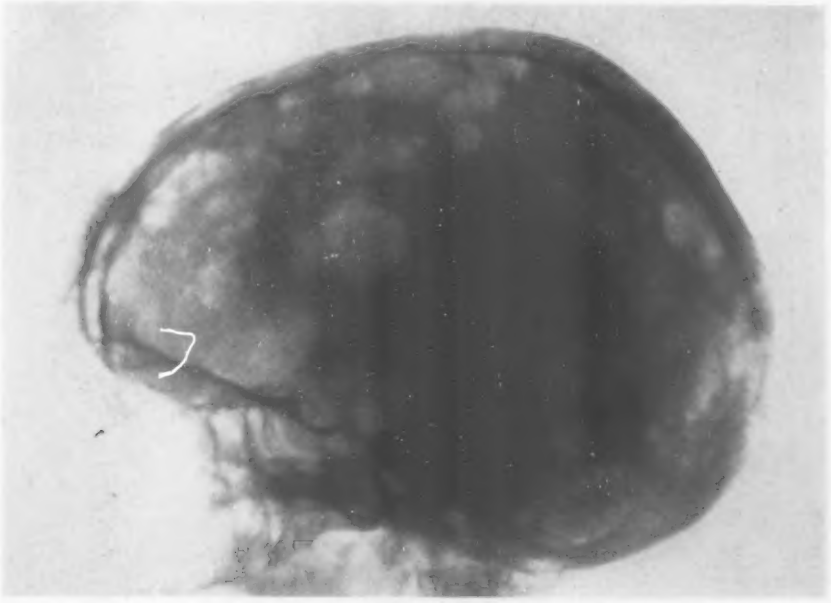

FIG. 16.—Skull.

stage invasion of the acromial process occurs and somewhat later the outer end of the clavicle is affected. From this stage the cancer extends gradually to successively adjacent areas in these bones. Quite commonly a second area of invasion occurs at the inner end of the clavicle and spreads outward to meet the invasion extending from the outer end. We disagree with the commonly expressed statements in the literature that metastases to the clavicle and scapula in breast cancer are relatively rare findings.

Studies of the humerus habitually reveal a gradual progressive extension downward and the great majority of patients die before the cancer as shown by X-ray reaches the elbow. In only six of our present series of 101 cases did the cancer extend below the elbow. In four of the earlier of these six and in several other similar cases we have seen (*a*) the radius—usually at a short distance below its head and best shown in supination as X-ray pictures taken in pronation superimpose the shadow of the ulna over the site of

radial invasion—was always invaded before the ulna; and (*b*) invasion of the radius only occurs after the disease has extended in the humerus to within two inches of the elbow and usually the X-rays fail to reveal evidence of metastasis in this lowermost two inches of the humerus before the invasion of the radius is demonstrable. We have never seen metastasis below the elbow in the absence of metastases throughout the greater part of the length of the humerus.

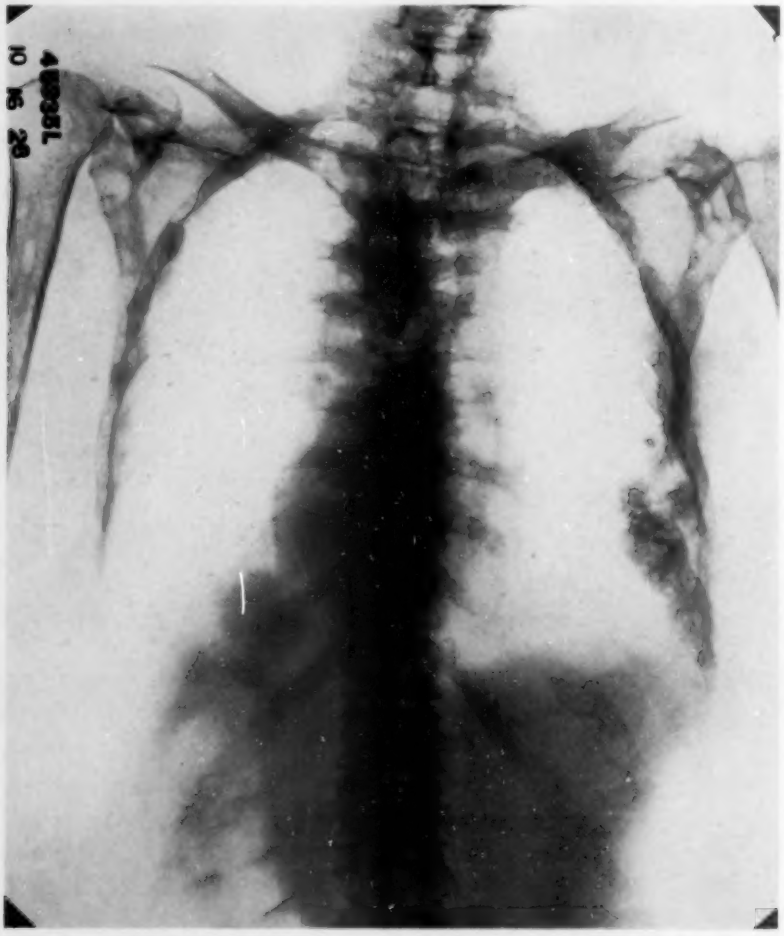

FIG. 17.—Post-mortem röntgenogram.

Usually several weeks intervene after invasion of the radius before disease is demonstrable in the ulna, commonly at a variable distance from its upper end. The metastases then spread upward and downward finally involving practically the entire shafts of the radius and ulna before metastases are shown in the bones of the wrist and hand. We have never seen metastases in the wrist or hand in the absence of extensive involvement of all three bones of the arm and forearm. As a general rule it may be stated that in metastases in the upper extremity the most advanced destruction is

found at or near the upper end of the humerus with a gradual lessening in severity downward to the most distant site of invasion.

The vertebræ are frequently the first site of metastases. Apparently almost any vertebra from the mid-cervical to the last lumbar may be the first one affected but there are three sites of special predilection. The first invasion of vertebræ occurs most frequently in the third to the sixth thoracic, less often in the upper lumbar and somewhat less commonly in the lower cervical. Not infrequently vertebral metastases may appear in two of these sites simultaneously.

The first X-ray evidence of metastasis anywhere is found exceptionally in the bones of the pelvis and very rarely in the femur.

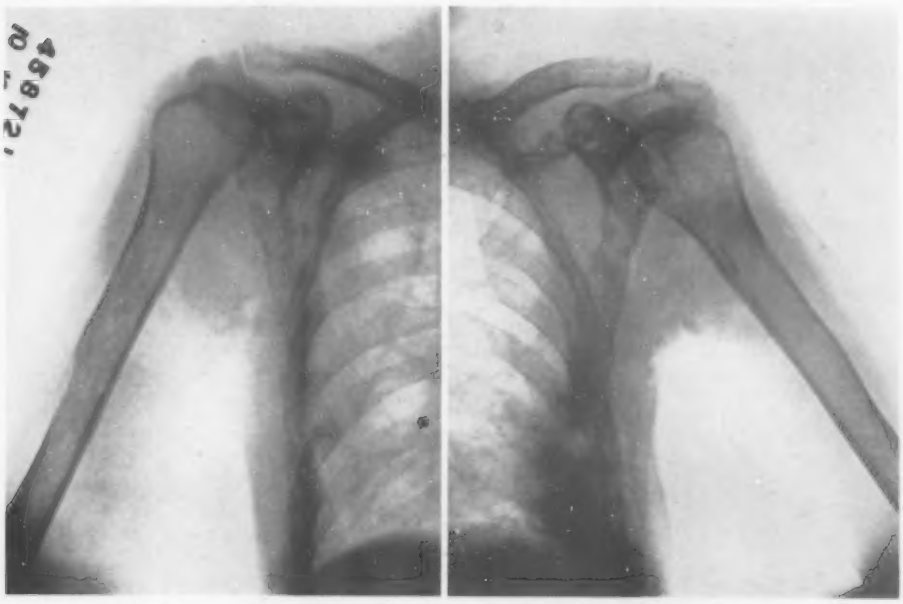

FIG. 18.—Left shoulder girdle and humerus.

FIG. 19.—Right shoulder girdle and humerus.

Invasion of the femur usually begins in the head and is then nearly always associated with similar invasion of the acetabulum and adjacent bone. As in the upper extremity, we find an orderly downward extension which gradually descends the femur to within a couple inches of its lower end, when the metastasis will make its first appearance below the knee, and affects the upper tibia before involving the fibula; it then progresses down these bones to near the ankle before invading the tarsus.

In both upper and lower extremities the bone invasion is usually bilateral and fairly equal in intensity and in progression on the two sides. Furthermore invasion in the femur, though a bit later in onset, keeps fairly uniform pace with the invasion of the humerus. The progress of the disease in the tibia and fibula is about on a par with that in the radius and ulna. In only two of our 101 cases—to be referred to later—has there been any noteworthy

FIG. 20.—Left humerus, radius and ulna.

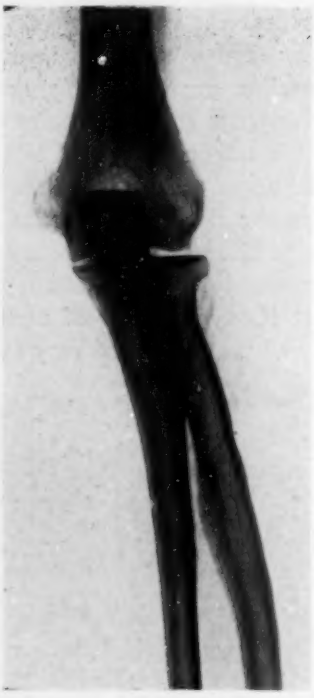

FIG. 21.—Right humerus, radius and ulna.

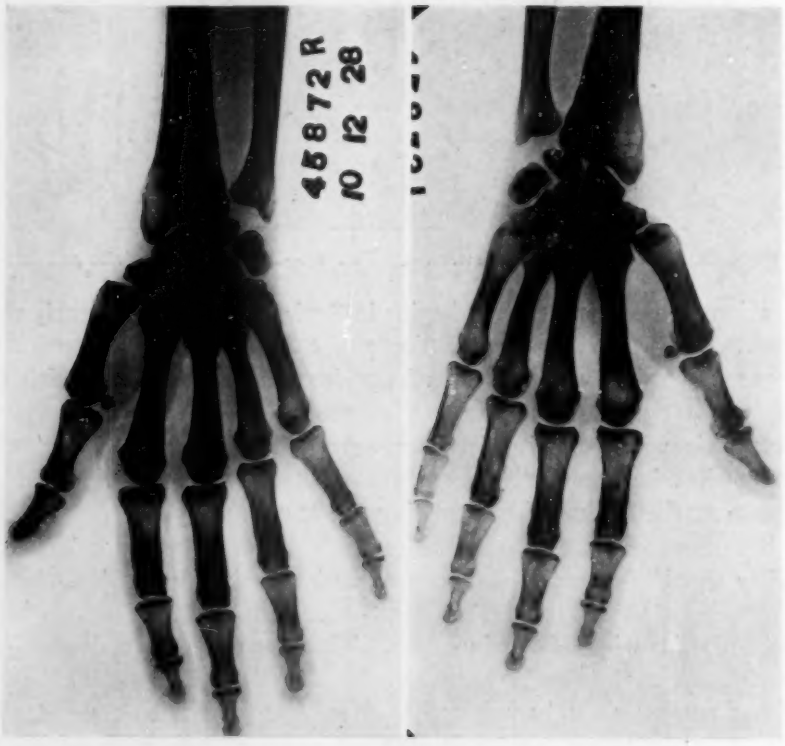

FIG. 22.—Right and left hands showing early invasion of some of carpals, metacarpals and phalanges.

departure from this gradual peripheral spread of metastases in the lower extremities.

It is inconceivable that blood-stream emboli or lymphatic emboli could give rise to the orderly extension of cancer in the bones such as we have described. Supporters of the theory of vascular emboli of cancer cells always causing bone metastases claim that the theory of lymphatic permeation has not been adequately proven. We feel justified in retorting that the

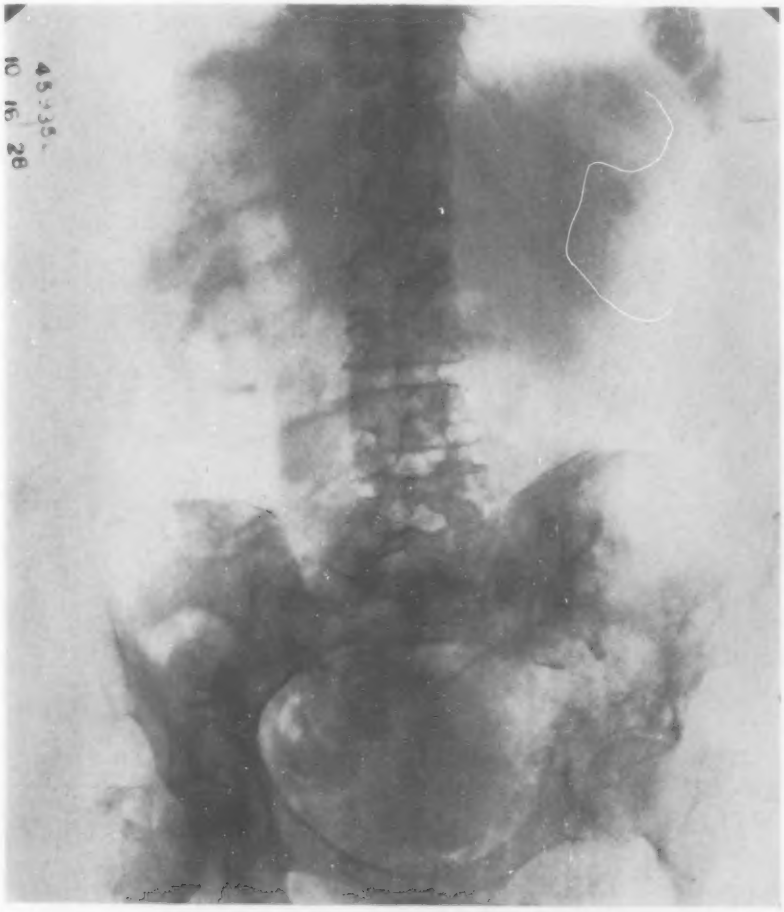

FIG. 23.—Lumbar spine.

vascular embolic theory has likewise not been proven. Lymphatic permeation of cancer cells is the only known process in the spread of cancer that could rationally account for our bone findings.

In the earliest stage of invasion anywhere, the bone affected usually presents a mottled appearance indicative of multiple foci of cancer developing simultaneously from lymphatic permeation rather than a single focus such as would be expected in blood embolism.

Sarcoma metastasis is unquestionably due to blood-stream emboli but beyond the primary invasion of the lungs from sarcoma in the systemic

circulation or of the liver from the portal circulation no one can predict the site of further manifestations of metastases. Aside from the lungs and liver it is characteristic of sarcoma vascular emboli to distribute metastatic deposits after a most haphazard and lawless fashion. Certain types of cancer—especially primary cancer of the liver and kidney—are particularly prone to metastasize to the lungs by way of the blood-stream. Cancer cells from the breast may also invade the blood-stream, especially in the terminal

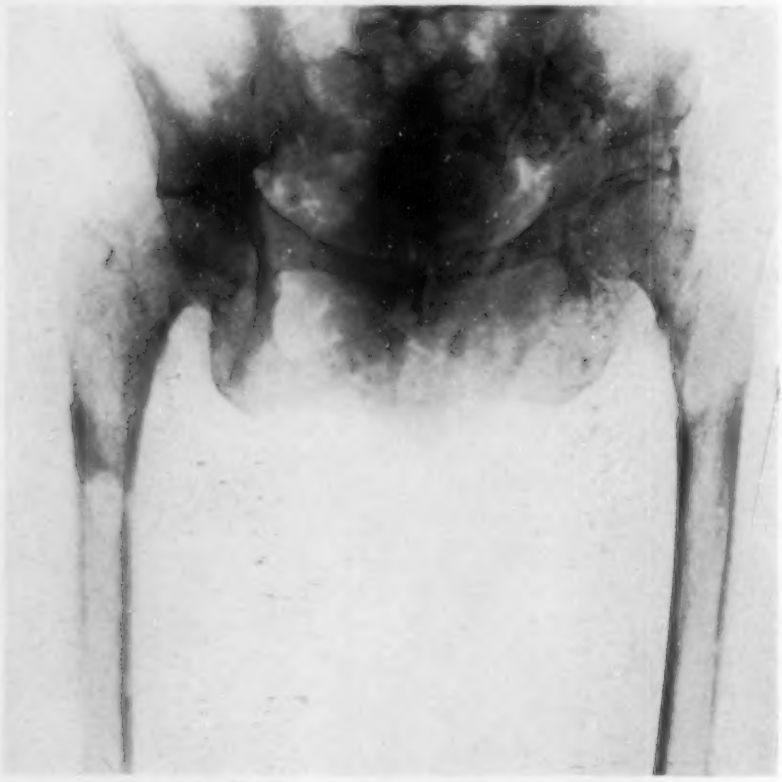

FIG. 24.—Pelvis and upper femora.

stage of the disease, but it is unusual to find evidence of vascular emboli at a distance from the breast other than in the lungs or brain.

In two of our series of 101 cases we believe the bone lesions were caused in part by vascular emboli. In our Case II the lesions in the right tibia, fibula and bones of the foot and ankle (Fig. 27) indicate vascular emboli as their origin because they are so much farther advanced than the lesions in the corresponding bones on opposite side and in both femora, which latter lesions are the ones customarily found. This case is the only one either in this series or in our entire practice in which we have seen advanced bone lesions anywhere below the knee. We believe that in Case II a vascular embolus lodged in the shaft of the tibia or fibula and started up a local nidus

of metastasis and from that nidus the cancer was extended by lymphatic permeation. The second case of probable vascular embolism occurred in a patient who was admitted with a pathological intertrochanteric fracture of the femur and extensive radiograms failed to show any other bone lesions. Further X-ray studies were not made until eleven months later when there were found the early metastases of lymphatic permeation in the homolateral shoulder girdle, ribs, thoracic and lumbar vertebræ and both femora. The intertrochanteric fracture had united. The great majority of pathological fractures unite with no special difficulties. This patient is the only one in this series of 101 in whom an advanced lesion in the femur was not associated with widespread lesions in other bones.

FIG. 25.—Right femur.

FIG. 26.—Left femur.

Except for the preceding two citations and for invasion by direct extension to ribs underlying the cancerous breast we believe lymphatic permeation is responsible for the bone metastases in our 101 cases.

The route of invasion to the shoulder girdle, we believe, is by way of the axilla. Cancer cells from the breast may reach the axilla either slowly by lymphatic permeation in the breast (Fig. 30) and along the deep fascia of the chest wall (Fig. 31), or more quickly by lymphatic embolism to the lymph

nodes and secondary permeation beyond them to reach the bones of the shoulder girdle. Before the days of the X-ray, Handley [2] evolved the theory of extension to the humerus taking place by permeation along the lymphatics lying just beneath the skin and fat and extending from the breast out over the shoulder and down the arm as far as the deltoid insertion to reach the humerus. This route may apply in certain exceptional cases in which the

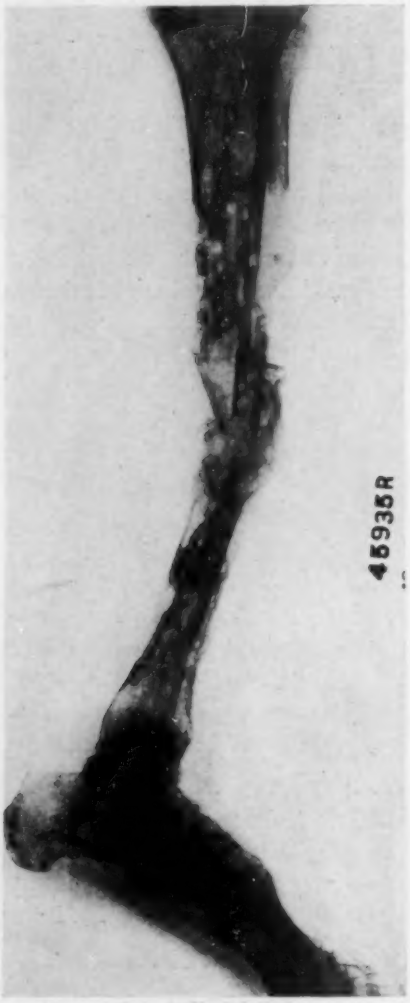

FIG. 27.—Right leg and foot showing invasion of all bones.

FIG. 28.—Metastases in left tibia, fibula, oscalcis and astragalus.

first invasion of the humerus appears below its head and neck. In his most recent paper on bone metastasis Handley [3] concurs in our view that the usual route is deep to the pectoral muscles rather than superficial to them.

The metastases to the shoulder girdle in fifty-four of our cases were bilateral in twenty-four, homolateral only in twenty-three, and contralateral only in seven. Radical breast amputation had been performed on four of

the bilateral cases, fifteen of the homolateral and four of the contralateral. The occurrence of metastases only in the shoulder girdle contralateral to the breast cancer might be explained by the operation on four having excised all

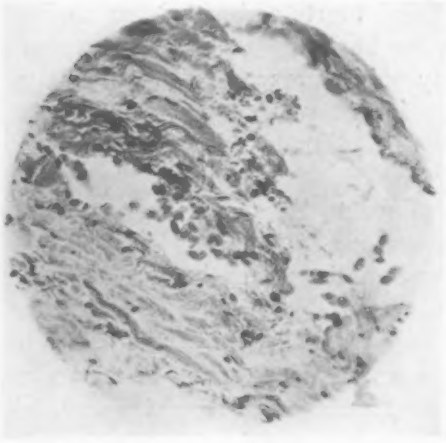

FIG. 29.—Posterior parietal peritoneum showing cancer cell permeation of lymphatic vessel running diagonally across middle of photomicrograph. Courtesy of Dr. W. P. Belk.

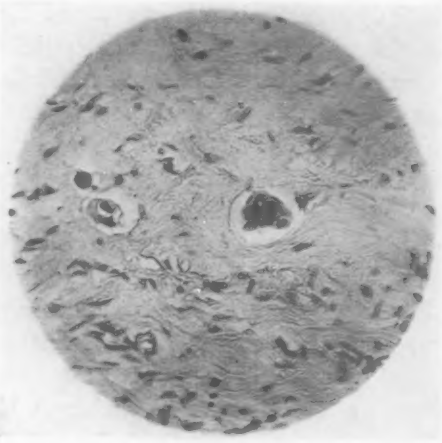

FIG. 30.—Breast tissue at a distance from the primary tumor. Permeated cancer cells shown in the cross section of two lymphatic vessels. Courtesy of Dr. E. A. Case.

of Handley's[2] microscopic growing edge of permeation in the direction of the homolateral axilla and having failed to excise it toward the contralateral axilla. Contralateral invasion only in the three non-operative cases suggests

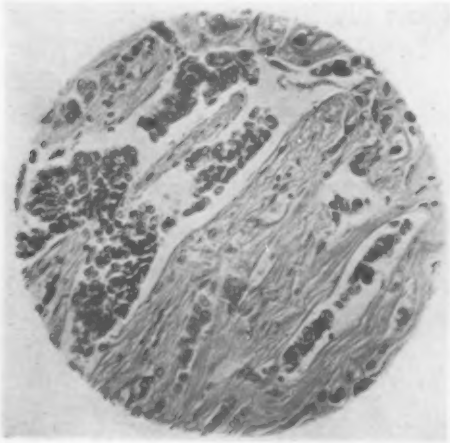

FIG. 31.—Subcutaneous tissues of chest wall. Longitudinal sections of several lymphatic vessels containing permeated cancer cells. Courtesy of Dr. Herbert Black.

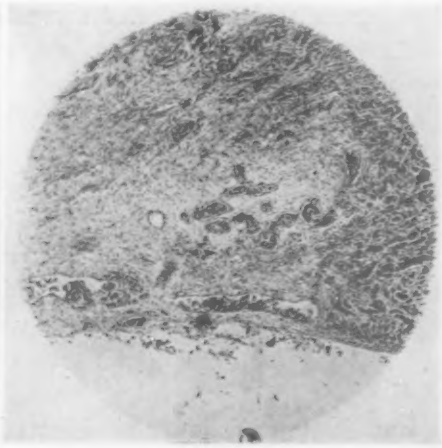

FIG. 32.—Meninges and brain. Longitudinal and cross sections of several lymphatic vessels showing permeated cancer cells. Courtesy of Dr. N. W. Winkelman.

the possibility of the lymphatics to the homolateral axilla having been blocked by abnormality or disease preceding the cancer.

By permeation upward from the axillary lymphatics cancer cells can be conducted to the lower cervical vertebræ first, and later to the upper cervical

and finally to the skull, dura (Fig. 32) and brain. We have not made any special observations bearing on the lymphatic permeation which causes widespread invasion of the ribs.

We have repeatedly seen chains of cancerous tubercles along the course of the lymphatics in one or more of the third, fourth and fifth interspaces on the pleural aspect of the chest wall leading backward to the third to sixth thoracic vertebræ. The cancer cells may gain entrance to these intercostal lymphatics either (*a*) by direct extension from the breast through the chest wall or (*b*) by lymphatic permeation or embolism to the lymphatic nodes lying along the internal mammary artery.

Vertebral metastasis may remain confined to the one or few vertebræ first affected but more commonly the metastases extend more widely and frequently involve the entire spine. Because of the absorption of lime salts it is often difficult to obtain good röntgenograms of the spine (Figs. 10 and 23). This difficulty is further enhanced by crumpling up of the bodies of several vertebræ in many of the very late cases. Compression of the bodies of one or several vertebræ with or without angulation of the spine may, but seldom does, cause paralysis by pressure on the spinal cord. More commonly spinal paralysis, even when sudden in onset, is due to metastases growing in the epidural space [4] and may then be overcome in some cases by vigorous irradiation.

The roots of the spinal nerves may be either compressed by secondary cancer of the bone or, more often, of the soft tissues, or actually invaded by cancer cells giving rise to widely distributed pain and tenderness in the areas of distribution of the affected nerves (Case II) irrespective of whether or not the bones underlying the pain areas have been invaded by cancer. The pain and tenderness of spinal nerve irritation are often erroneously ascribed to an underlying bone metastasis. Patients commonly exhibit evidence of quite as much tenderness on pinching of skin, fat and muscle as they do on making a corresponding amount of digital pressure against the bone, regardless of whether the latter is invaded or not. We have exceptionally found unmistakable evidence of tenderness in metastatic bone lesions. Spinal nerve irritation often causes pain and tenderness in the anterior abdominal wall where they are all too commonly and wrongly blamed on one or another intra-abdominal lesion. These pains are often relieved by irradiation over the spinal origin of the affected nerves.

In order to explain our views pertaining to metastases of the lumbar vertebræ and the bones of the pelvis and lower extremities it will be necessary to digress for a few moments from a direct description of lymphatic channels leading to the bones.

We attend the autopsies on our breast cancer cases and some of our observations on evidence of lymphatic permeation within the abdomen seem worthy of mention particularly as some of them have a definite bearing on metastases to bones below the level of the diaphragm.

Concerning the method of extension of cancer cells within the abdomen secondary to breast cancer we differ both from the generally accepted view that they are due to blood-stream emboli and from Handley's view [2] that they are due to "transcœlomic transplantations."

Excluding the cases which die of some intercurrent disease before the breast cancer has run its course we find extensive evidence of intra-abdominal lymphatic permeation in over 80 per cent. of cases autopsied.

A fairly constant finding, but one easily overlooked if special search is not made for it, consists of enlargement and induration of the lymph nodes along the abdominal aorta, the common iliac arteries, often also along the internal and external iliac arteries and much less frequently along the femoral arteries into the saphenous and inguinal regions. Microscopic examination may reveal cancer in this entire chain of lymph nodes, but more commonly cancer is found only as far down as the deep inguinal nodes and not in the superficial inguinal and saphenous nodes even though the latter be enlarged. These enlarged lymph nodes are certainly not due (1) to transplants as they lie under the posterior parietal peritoneum and there is usually lacking a lesion of the peritoneum from which cancer cells could be brushed off to form the transplants; (2) to lymphatic embolism because (*a*) the lymphatic current is in an upward direction, and (*b*) they are often found in the absence of any other pelvic or lower abdominal metastasis; nor (3) to blood-stream embolism because it is inconceivable that emboli should so habitually involve this entire chain of nodes—often in the absence of other noteworthy abdominal metastases (Case II). Microscopic examination of the lymph channels associated with these nodes commonly shows extensive lymphatic permeation (Fig. 29).

Cancer cells from the breast may reach these deep lymphatic channels and nodes (1) by permeation downward from the chest along the aorta when cancer from the breast has invaded that cavity early, usually by lymphatic permeation; (2) by lymphatic permeation as described by Handley [2] along the deep fascia of the chest wall and through Handley's "dangerous epigastric triangle" [2] to reach the lymphatics of the anterior parietal peritoneum, from which point we have occasionally seen cancerous tubercles studding the peritoneum either (*a*) along the anterior, lateral and posterior parietes or (*b*) along the diaphragm, to the aortic region; or (3) by permeation through the lymphatics from the breast along the deep fascia to penetrate the abdomen in the lumbar region as described by Handley [2] but not recognized in any of our cases.

Often the enlarged lymph nodes as described constitute the major or, aside from the liver, the only (Case II) macroscopic evidence of intra-abdominal cancer. When the abdominal metastatic lesions are somewhat further advanced discrete tubercles will be found usually first in the mesojejunum and these tubercles are largest at the root of the meso and diminish in size toward the jejunum. The first nodules to appear in the jejunum are at its mesenteric attachment and they are older and larger than the nodules

finally appearing on its anti-mesenteric aspect. These mesenteric nodules are covered by peritoneum; hence are not transplants and their distribution is too constant to be explained by vascular emboli. They appear first in the mesojejunum, apparently because the lymphatics in this structure are permeated earlier from the aortic lymphatics than are lower lying mesenteries and mesos.

At a somewhat later stage nodules of the same type may be found widespread in or on mesentery, mesos, and large and small gut and under the parietal peritoneum, which latter at first can be slipped back and forth over them. This applies in some instances we have seen in the deposit at the bottom of the cul-de-sac (in cancer either of the breast or of the stomach) so commonly regarded as always being due to transplantation but being under the peritoneum must, in these cases if not all, be due to permeation.

In their latest stage these nodules may invade the covering peritoneum and project above it and therein resemble transplants which at first are always supraperitoneal but growing inward they may invade the peritoneum. When nodules have reached this stage we not infrequently uncover entirely similar nodules in various places, as, for instance, within the area of fusion between large gut and posterior parietal peritoneum, which are entirely inaccessible to transplants. We have only very rarely seen nodules superimposed on peritoneum in the manner to be expected from early transplants. For these and other reasons we believe the dominant process of dissemination of breast cancer cells within the abdomen is lymphatic permeation. Those who do not believe the theory of lymphatic permeation of cancer cells should study the excellent examples of it in the slides of the brain, lung, pericardium, and adrenal gland shown by Dr. George M. Robson [5] in a cancer other than of the breast.

The aortic and iliac lymph nodes and main channels lie in intimate contact with the lumbar spine and sacrum, and collateral lymph channels extend to the lowermost ribs and bony pelvis. Permeation apparently takes place with great rapidity down these channels in a direction the reverse of the normal lymph current and gives rise to metastases in the lumbar vertebræ, lower ribs and pelvic bones.

Handley [2] originally expressed the opinion that metastasis to the femur was due to cancer cells permeating through the lymphatics lying on the deep fascias of the anterior chest and abdominal walls and penetrating the femur at the great trochanter. Years ago we were impressed by the absence of cutaneous and subcutaneous nodules overlying these lymphatics in patients having extensive invasion of the bones of the lower extremity. Handley's theory as to the route of extension would have been more plausible had superficial nodules as described in our Case I been a frequent finding in association with metastases to the upper and lower extremities. In our six cases showing metastases below both elbows and below both knees and in another case having metastases below the knees but not below the elbows there were no skin nodules in three (including our Case II) of them. One

developed a few skin nodules in the immediate vicinity of the primary tumor a few weeks before death. In another patient superficial nodules extended from the angle of the jaws down the back to the buttocks and down the chest and abdomen to the upper anterior third of the thighs. Another patient was our Case I, who presented the most extensive skin nodules that we have seen anywhere. Handley [2] states that skin nodules never extend below the middle of the upper arms nor below the upper thirds of the thighs but our Case I exceeded both those limits. The seventh patient was a post-operative case, described in detail elsewhere,[6] who developed two nodules near the umbilicus a few weeks before death. The very late development of skin or subcutaneous nodules similar to hers over either the chest or abdomen in post-operative cases is commonly ascribed to cancer cells lying dormant, locally enclosed in fibrous tissue. We surmise, however, that many of these cases, especially in the presence of extensive visceral metastases, are due to cells permeating from within outward through the wall of the chest or abdomen. The complete modern breast operation, especially along the lines laid down by Handley,[2] supplemented by irradiation, is seldom followed by external recurrence. In these days patients exhibit skin nodules far less frequently than bone metastases.

When we found that röntgenograms of our early cases showed the first invasion occurring most commonly in the head and neck and only exceptionally lower down in the femur we searched for another route and discovered the chain of cancerous lymph nodes and permeated lymphatics which we have described as lying along the main abdominal blood-vessels. It is our belief that the usual route of invasion of the femur is by permeation along these intra-abdominal and intrapelvic lymphatics and thence along lymphatics in the ligamentum teres. We think Handley [2] was unduly influenced by finding six homolateral to two contralateral cases of metastases to the femur in his early material and our views thereon have been expressed elsewhere.[6] In our present series of cases the femoral metastasis was bilateral in twenty-seven, homolateral in two and contralateral in three. In his recent paper Handley [3] expresses approval of the route we describe. After the cancerous invasion of the femur gradually extends downward, permeation of the lymphatics of the soft tissues overlying the knee-joint occurs sufficiently early to produce X-ray evidence of metastasis at or near the upper end of tibia before it is shown in the lowermost femur. Similarly, permeation of lymphatics of the soft tissues carry cancer cells from the shaft of the humerus to the upper radius usually before the lowermost end of the humerus shows involvement by X-ray.

In our opinion the relative infrequency of metastasis in the bones below the knee and elbow is not due to the rather prevalent opinion that these bones possess some form of special immunity, but is due to death occurring from extensive cancer metastases before sufficient time has elapsed for the slow-moving lymphatic permeation to reach these distant bones. Were the average duration of life after the onset of bone metastasis one or two

years longer invasion of all the bones down to the terminal phalanges of the fingers and toes would be fairly common.

For practical purposes it may be assumed that if skiagrams of ribs underlying the breast, of the shoulder girdles, of the spine from the mid-cervical region to the sacrum and of the pelvis fail to show metastasis then bone metastasis is not likely to be found elsewhere. The exceptions to this statement are the cases similar to our Case II in which vascular emboli are carried early to distant bones. This occurrence is too rare to justify taking skiagrams of the entire skeleton in the search for a bone metastasis that might contraindicate operation. Any otherwise unexplained pain in a bone, however, does call for special skiagrams of it.

We cannot predict which one or more of the lymphatic routes to skin and fat, to bones, or to thoracic or abdominal viscera, permeation will elect to follow in any given breast case but once we obtain evidence of permeation having started on one or more routes we can make a reasonably accurate prediction of the metastatic deposits that will follow and this we could not do if blood-stream were the main factor in disseminating cancer cells.

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OSTEITIS FIBROSA*

CASE REPORTS SUGGESTING A TRAUMATIC ORIGIN

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The multiplicity of names given to bone tumors of the giant-cell and fibroblastic group attests to the uncertainty as to their etiology and to the extreme diversity of histological appearances presented. Cases bearing a singular similarity to one another have been designated osteitis fibrosa cystica, osteodystrophia juvenilis, osteodystrophia fibrosa localisata, giant-cell tumor, bone cyst and chronic fibrous osteomyelitis. The general acknowledgment of a single etiological theory for the entire group would set some of this chaos in order. We propose to outline a conception of the disease based upon the fundamental hypothesis of a primary trauma to the bone. Such a conception affords a basis for grouping several supposedly distinct pathological entities as consecutive phases of a single disease process. Moreover it provides a plausible explanation for otherwise irreconcilable clinical and röntgenological phenomena.

A generalized form of fibrosing osteitis was described by von Recklinghausen and bears his name. The localized form to which this discussion is limited has received subsequent recognition. Bloodgood was a pioneer in emphasizing the benignity of giant-cell tumor and advocating conservative treatment. To this date, however, the appellation of giant-cell sarcoma (Ewing) retains for it the suggestion of malignancy. Several recent attempts have been made to draw into a single category previously distinct but interlocking bone dystrophies. Garland, for example, incorporates into a single group osteitis fibrosa cystica, osteitis deformans (Paget's), osteomalacia, giant-cell tumor and bone cyst. By all odds, the most comprehensive and brilliant presentation of the subject from a pathological viewpoint is the recently published study of Geschickter and Copeland. They have painstakingly reviewed over 400 cases of tumors of the giant-cell group, including giant-cell tumor, osteitis fibrosa, solitary bone cyst, epulis and xanthoma, together with several intermediate "variants." The conclusion drawn is that the first three named are stages in a single process and have the common primary factor of trauma. This presentation is in accord with this view. We have borrow liberally from their writings in elucidating the transitions from one stage of the pathological picture to another. In appropriating the theory promulgated by Geschickter and Copeland, we have added nothing to their masterful discussion of the pathological processes involved. However, in contributing our confirmatory evidence gathered from clinical obser-

* Read before the conjoint meeting of the Philadelphia Academy of Surgery and the New York Surgical Society, February 13, 1930.

vations, we are compelled to admit certain slight modifications of the original thesis of these authors, in order to bring the theory into close conformity with clinical facts.

Inflammation.—There are many arguments against an infectious origin. In the first place, cultures taken at operation are uniformly sterile. Phemister, who regards the condition as inflammatory, was able to cultivate a staphylococcus in a single instance but could not exclude a skin contamination. Moreover the histological picture is not that of an infiltrative reaction to bacterial invasion. Small round cells are conspicuously absent. The stage in the process which will be subsequently described as subcortical hæmatoma formation is illuminating. Arguing from an analogy of the behavior of hæmatomata in general, the presence or absence of infection will determine subsequent developments. If the blood clot is infected, there will be cellular invasion, degeneration of hæmatogenous coagulum, and eventually suppuration. However, in not a single recorded case has suppuration been observed either superficially, subperiosteally or within the medulla. In the absence of infection the blood elements will be gradually replaced by fibrous tissue. It is the latter course which is pursued by the disease under consideration. Furthermore, the symptomatology is not that of an infection. There are two major symptoms, namely, pain and swelling. Pain may result from distention of the richly enervated periosteum if, as in Case IV, the lesion be peripherally placed. Otherwise the disease runs a relatively painless course until attention is directed to swelling over the bone or the occurrence of pathological fracture (Case I). Some cases, indeed, are discovered only by an incidental röntgenological examination. Finally, the clean healing following fracture or operative incision provides an additional bit of evidence against infection. Such healing could not occur with regularity in an infected bone.

Neoplasm.—The lesion certainly does not behave as a malignant growth. Its only malignant characteristic is a tendency to mild recrudescence or perhaps recurrence. If neoplastic at all, it must be quite benign. However, its cellular morphology discloses neither a hyperplasia of tissue normal to the region involved nor an overgrowth of abnormal embryonic elements as in the blastomata.

Trauma.—This provides the most likely explanation for the disease. It is noted in the preponderant number of case histories. Its absence from the history, moreover, is not exclusive since many cases are in children and the slight injury necessary may readily pass unnoticed by unobservant adults. Certain features are very significant. The bones most often affected are: the humerus near the greater tuberosity, the radius at the lower end, the tibia at one or the other extremity, and the femur near the greater trochanter. These are likewise the common sites of injury in children. The portion of the bone involved is also characteristic. In children it is always on the metaphyseal side of the epiphysis. In adults it may be primarily in the shaft or have assumed this position secondarily as a result of growth in the

length of the bone. Case IV represents an adult of the first class with a history of recent trauma over the tibia. The rarefaction seen in the X-ray is near the cortex. There is periosteal proliferation on the external aspect and eburnated bone on the opposite side of the lesion. On the other hand, a lesion, originating near the epiphysis and shifting with the growth of the bone prior to discovery, would be expected to occupy the central medullary portion of the shaft. Accordingly the respective ages of the patient at the time of injury and at the time of observation together with the length of the intervening period are all factors to be considered in interpreting the changes encountered in a given case.

A traumatic origin appears to explain adequately the sites of election of the lesion. It likewise reconciles the divergent histological changes encountered by interpreting them as consecutive phases of a single pathological process and not as distinct entities. The sequence is somewhat as follows: A child sustains a trauma to the bone at one of the favorite sites previously mentioned. Hæmorrhage occurs within the cortex. The blood, seeking an outlet, finds it most readily in the cancellous tissue producing a juxta-epiphyseal hæmatoma. The next step is well described by Geschickter and Copeland. It is concerned with the giant-cells whose function in ossification of callus (represented by the hæmatoma) or preëxisting cartilage is an osteoclastic one. They push their way from the cortex into the central portions, blazing a trail for new vascular channels. Normally their excursions are limited by surrounding fibroblastic proliferation. In this instance the latter has been crippled by interference with the blood supply of the overlying periosteum. The result is an imbalance of the normal mechanism of osteogenesis—"fibro-ostosis" by fibroblasts on the one hand and osteoclasis by giant-cells on the other. The latter get out of hand and the so-called giant-cell tumor results. In certain cases such an imbalance does not exist. Instead the more normal fibroblastic replacement occurs. Such a response with fibrous replacement is encountered in the shaft where a thick cortex affords restraint. Giant-cell hyperplasia occurs near the metaphysis where cartilaginous tissue and cancellous bone abound. If the former course is followed with resultant osteitis fibrosa, cysts may or may not be found, depending upon the degree of degeneration. In the further alterations in morphology, the rigid shell of cortical bone surrounding the lesion exerts its influence. Nature is not able always to fill the entire space with fibrous tissue. In such cases there is only a fibrous envelope, the central portion being filled with semifluid material or blood. Thus the final stage is the solitary bone cyst.

One fact remains to be explained. The maximum number of bone cysts occur prior to the twentieth year. The favorite age incidence of giant-cell tumor is the decade immediately following. According to the sequence just outlined, this is difficult to understand. Ewing, however, states "a history of trauma and the presence of hæmorrhage and pigmentation in the walls of the cysts seem to show that the presence of blood coagulum influences the

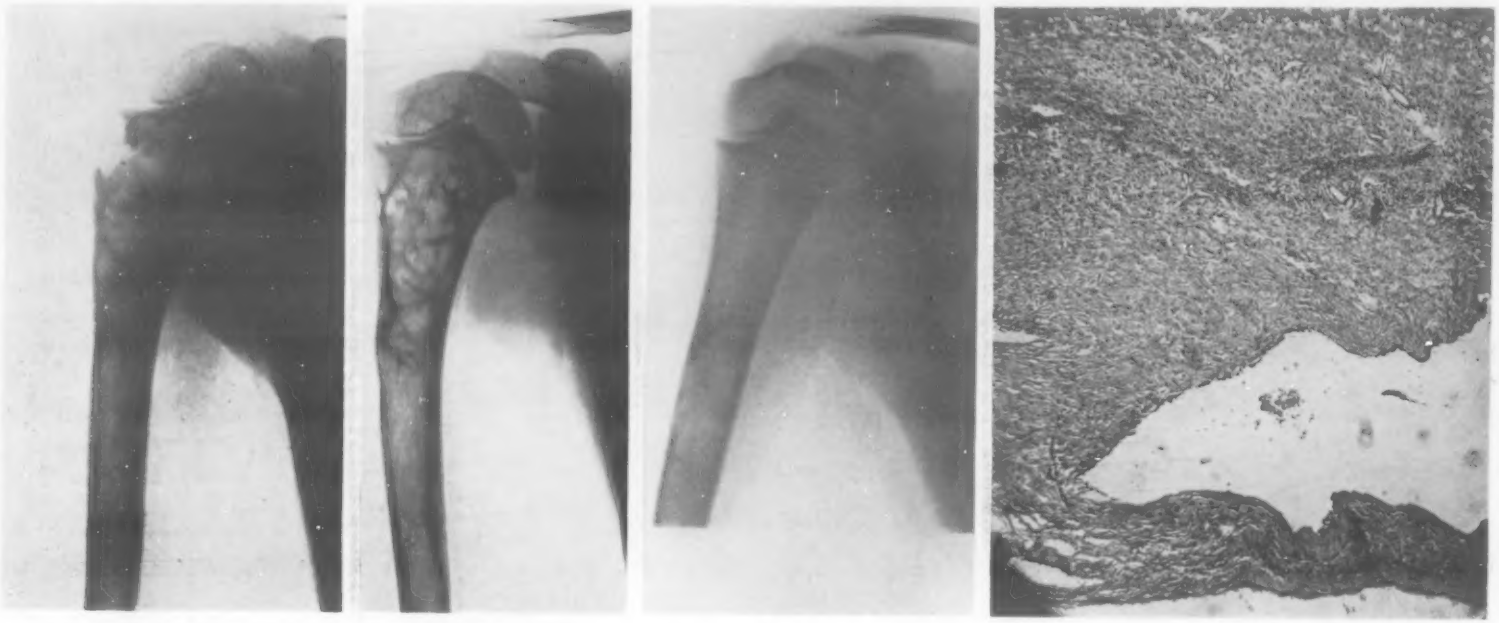
development both of cysts and of giant-cells." It is quite possible, therefore, that bone cysts may arise in many cases directly from the hæmatoma by cystic softening without the intermediary phases of giant-cell tumor or osteitis fibrosa.

Operative findings.—Exposure of the lesion at operation may disclose either one or two appearances. There may be an elevated eburnated cortex overlying a hæmogenous area of soft brownish tissue. On the other hand, removal of a thin bony shell may reveal an encapsulated cystic growth, comprising fibrous wall and fluid or semi-liquid contents. In the latter case the entire lesion may be readily stripped from its nest in the bone. The trabeculation often seen in X-ray photographs suggests a framework of interlacing osseous fibrils. This is not encountered in the lesion. The X-ray appearance is due actually to inequalities in the thickness of the overlying cortex and not to trabeculation of the growth.

Treatment.—In addition to X-ray therapy and operation, spontaneous healing following pathological fracture must be taken into account. The last is to be regarded purely as a decompression. Operation also serves to decompress but permits at the same time, of extirpation of abnormal tissue. Irradiation aims to retard abnormal tissue growth. In the light of our experience, any single method of treatment may be inadequate. In the first case, an apparent arrest by fracture later required X-ray treatment for a recrudescence of activity. The second case showed reactivity after an operation of supposedly total extirpation. The third patient improved temporarily under irradiation but subsequently required operation. He further illustrates the danger of interference with bone growth incident to prolonged irradiation over an epiphysis.* The failure of any single method to effect a cure in every case indicates that a combination of operative and X-ray treatment approaches nearest to the ideal, at least in the present state of our knowledge of the condition. The tendency to reactivity or recurrence makes it imperative to keep patients under continued observation.

CASE I.—Boy, aged seven years, admitted to University Hospital March 2, 1925. The history was completely negative prior to a fall while at play on the day of admission. Resultant injury to left arm shown by X-ray to be a fracture of surgical neck of humerus at site of a giant-cell tumor. Dressing applied. X-ray three weeks later showed normal healing. X-ray taken January 27, 1926, showed some increase in size of lesion and three courses of X-ray treatment were given during the year. There was no disability at this time or subsequently. The picture on September 16, 1916, showed considerable bony deposition but a superficial "blister" producing a periosteal bulge. After the third course of treatment, January 13, 1927, the bone appeared solid. At this time the shifting of the site of the lesion away from the metaphysis as a result of bone growth was very evident. At a final examination, four and a half years after the original fracture, October 27, 1929, the bone was completely calcified and the lesion appeared to be healed.

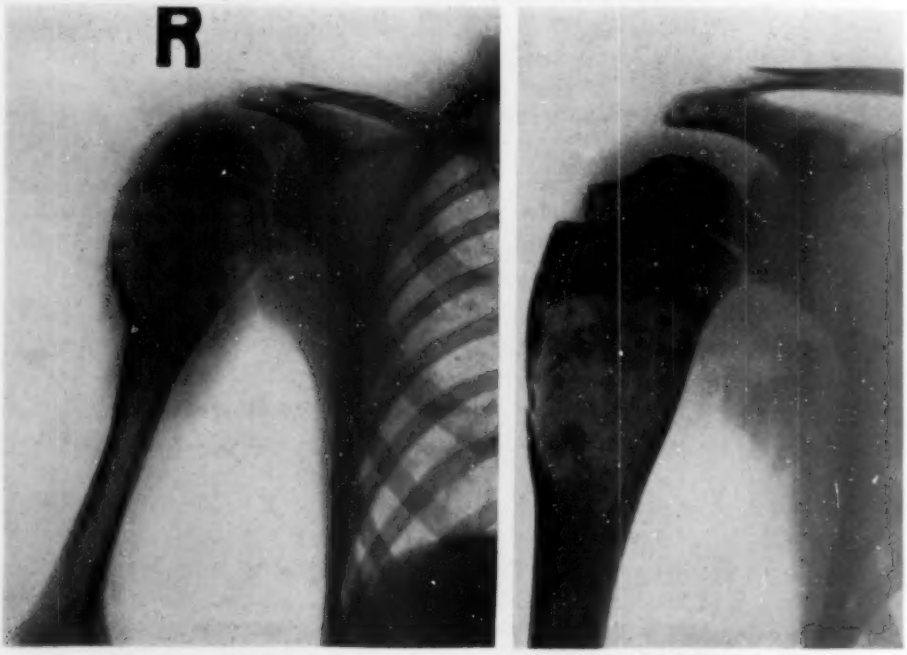
* Our attention has been called to a case in the files of the Roentgenological Department of the University Hospital in which apparent interference with bone development has occurred from the growth of the lesion alone as the case had not received irradiation. This is a question which will require further investigation.



1a 1b 1c 1d

FIG. 1a.—Case II. X-ray of humerus on admission (July 1, 1925) (Nine months after original trauma). 1b.—Six months after operation (January 26, 1926.) Slight amount of healing. 1c.—Five and a half years after operation (February 12, 1930). Note shifting of the lesion down the diaphysis due to growth in the length of the bone. 1d.—Microphotograph of tissue removed at operation.

Case II.—Boy, aged 7 years, fracture (?) upper right humerus, October, 1924, caused by toy engine thrown by playmate. Two months later a fall upon the same arm caused a great deal of pain and a "growth" was noted on the arm. No further symptoms. Admitted to University Hospital July 3, 1925 for investigation of tumor. X-ray diagnosis, "Osteitis fibrosa cystica of upper right humerus." Left humerus, pelvis and femora normal. Operation, July 8, 1925, gas anæsthesia. Periosteum elevated and a very thin cortex opened. The lesion appeared to be a cyst with fibrous wall and fluid contents. Entire wall removed intact after evacuation of contents. Bone dust, obtained from a cranial operation in process at the moment, was introduced into the defect in the bone. Periosteum sutured. Wound closed without drainage. Pathological sections of tissue removed showed for the most part fibroblastic tissue. There were several areas, however, showing typical giant-cells. These cells were in the neighborhood of cartilage. Cultures were not made. X-ray, August 27, 1925, "Apparently new bone formation or



2a 2b

FIG. 2a.—Case III. X-ray of humerus one week after injury. Note the eccentricity of the lesion (February 26, 1928). 2b.—After operation (January 28, 1930) showing new bone formation and bone chips introduced into the cavity.

calcified blood clot." Five months later, January 26, 1926, firm bony union with no disability at the shoulder. Boy had played football in the meantime. X-ray showed no increase in the area of upper right humerus but there was only a slight amount of healing. Final examination five years and four months after original, February 13, 1930.

CASE III.—Boy, aged eight years. Injured by fall in which he struck shoulder against radiator. Pain was gone the next day. One week later mother observed an inability to raise the arm and a swelling over humerus, and had the boy X-rayed, May 26, 1928. The report was giant-cell tumor of upper right humerus. Irradiation was begun and continued at intervals for eighteen months. During this time there were no symptoms and the swelling diminished in size. Several X-ray examinations indicated improvement. On November 29, 1929, a new area of rarefaction was apparent below the upper end of the diaphysis. In addition it was noted that there was five-eighths of an inch of shortening of the arm. Operation was determined upon. This

was done January 3, 1930, under gas anæsthesia. The cortex was thin. A well-encapsulated cyst containing bloody fluid was removed intact. Chips of bone from the removed cortex were dropped into the cavity after light curettage. The periosteum was sutured and the wound closed without drainage. Healing was perfect. Cultures inoculated with the cyst contents showed no growth. Pathological sections were reported as showing mature fibrous tissue with degenerative change which might have been due to X-ray therapy and increased vascularity. *Diagnosis.*—Osteitis fibrosa crystica. X-ray examination January 28, 1930, showed some new bone formation.

Case IV.—Woman, age thirty years, injured by fall, May 9, 1929, in which she

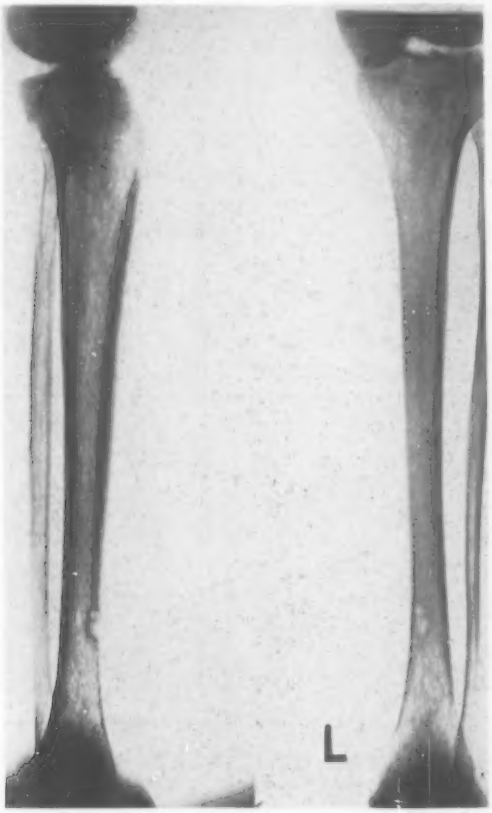


Fig. 3.—Case IV. X-ray of tibia (October 31, 1929). Six months after trauma (October 31, 1929). Note location of the lesion in the shaft (adult form).

caught her toe in a water vent and struck her tibia against the curbstone. The limb was not X-rayed at the time. Continued pain at site of trauma from time of injury until admission to the University Hospital October 30, 1929. During the interval she was X-rayed in three different hospitals, the first plate being taken six weeks after the injury. A review of these films showed no evidence of fracture at any time but a circumscribed area of rarefaction which slowly increased in size and was thought to be due to osteomyelitis. The patient had refused operation previously but consented thereto on November 6, 1929. Our röntgenologist reported the rarefied area previously noted and commented that it did not look like a localized osteomyelitis but its identity was uncertain. The blood Wassermann was negative. Operation under nitrous oxide disclosed a bulging periosteum and an eburnated thickened cortex. Beneath this there was an irregularly formed cavity containing soft brownish granular material. This was

removed with a curette and the cavity saucerized. Gauze packing in the wound. Culture was not taken. The pathologist reported whirls of mature fibroblasts, increased vascularity and some areas of mild round-cell infiltration. The pathological diagnosis was osteitis fibrosa cystica. Examination January 20, 1930, revealed good healing of wound, no pain. X-ray at this time was reported negative.

CASE V.—Girl, aged 2 years. The child's mother had noticed a tendency to drag the left leg in walking during the past six weeks. Examination showed a fullness and tenderness below the greater trochanter with a painful limitation of hip-joint motion. X-ray report: "Lesion involving the upper end of the left femur. It shows a marked

FIG. 4.—Case V. X-ray of femur before operation.

rarefaction with trabeculation and some expansion of the cortex. *Diagnosis.*—Possible giant-cell tumor."

Operation: February 21, 1930.—Thin flexible shell of bone opened exposing a cavity the size of a pigeon's egg. The cavity was lined with a fibrous membrane and filled with bloody fluid. The capsule was removed intact. The cavity was curetted and allowed to fill with blood.

Pathological Report.—Osteitis fibrosa cystica.

The patient is still in the hospital at the time this report is made.

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THE CURABILITY OF CANCER*

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I have thought it might be agreeable to you to speak of the brighter aspect of the usual dark picture of carcinoma. Accordingly I have culled from the records of the Follow-up Department of the Lankenau Hospital a few cases that may be of interest from the standpoint of the curability of cancer.

Before proceeding with my recital, however, let me say that curability of cancer depends on early detection, early treatment, site of the tumor, its nature, presence or absence of metastasis and finally on constitutional peculiarities of the individual concerned. Some day perhaps we shall know about the last-named factor in particular and the other factors in general. Some day we may know something about early cancer and at what stage metastasis begins. Indeed it is entirely possible that we may have a routine test for detecting early cancer and thus make a forward stride in the curability of cancer. We may then know why, as occasionally happens when a woman presents herself within forty-eight hours or even twenty-four hours after first noticing a lump in the breast, axillary metastasis can already be detected. There is no question in medicine that demands and is getting more attention and more intensive study than the question of the how, why, and whither of tumor formation.

Cancer is always considered a disease of middle life, that is, as occurring beyond the fifth decade, although it is not unusual to observe it before that period. When it does develop earlier, however, it usually runs a rapidly fatal course. Like all rules, this has its exceptions. Let me cite two encouraging examples.

Case I.—(Hosp. No. 3245/21.) Male, aged thirty-four years. Admitted November 2, 1921. Operation November 5. *Large carcinoma at pyloric end of stomach.* Subtotal gastrectomy done. Pathological report: "Mucoid carcinoma." For three years prior to admission, patient had suffered from digestive trouble, often seeking medical advice for same. Four months before admission, began to lose weight and strength very rapidly. Required blood transfusion (at another hospital) two weeks before admission to the Lankenau Clinic. In the eight years since operation he has been seen at intervals of six months and at each visit reported excellent health, no digestive trouble except when over-eating.

Case II.—(Hosp. No. 626/23.) Male, aged forty-four years. Admitted February 25, 1923. Operated March 7, that is, six years ago. At that time, gave a history of eight years of periodic attacks of indigestion lasting one month and then disappearing for several months. The rest of the syndrome was less typical of ulcer than this item so that a diagnosis of pyloric obstruction was made on the basis of X-ray reports and the usual test meal, etc. For the past three years, the most annoying feature of the attacks was nausea, vomiting of undigested food, sticking pain in the epigastrium, all coming

* Read before the joint meeting of the New York Surgical Society and the Philadelphia Academy of Surgery, February 13, 1930.

on about two hours after meals. Except for a rather distended stomach the physical examination was negative. Operation revealed an old duodenal ulcer surrounded by inflammatory tissue. Subtotal gastrectomy was done. Pathological report: "Carcinoma simplex." Patient has been seen at regular intervals and has never had any further trouble. At his last visit, December 11, 1929, a fluoroscopic examination was made, which showed good function of the new opening and an indefinite deformity of the contour of the stomach at the line of resection.

Several cases of cancer of the breast selected for their long post-operative history also illustrate the fact that cancer does not necessarily mean hopelessness.

CASE III.—(Hosp. No. 804/21.) Woman, aged fifty years. *Carcinoma of both breasts.* Sixteen months before admission noticed a slight sanguinopurulent fluid from left nipple. One week prior to admission noticed a slight lump and sense of pressure in left breast. Nothing noticed in right breast. On examination, the left breast presented a hard mass, size of an egg, in the center of the breast. Nipple was retracted and exuded blood during manipulation. No apparent axillary involvement. The right breast was somewhat harder than normal and had a crust over the nipple. Operation: Radical amputation of left breast. Simple amputation of right breast. Pathological report: "Left breast: ductal adenocarcinoma. Lymph nodes negative for metastasis. Right breast: very early medullary carcinoma and chronic cystic mastitis." Since operation the patient has never had the slightest complaint. She has been coming to the clinic regularly and at her last visit, eight years after operation, there was no sign of recurrence in either breast, she had good motion of both arms and was able to do her heavy housework.

CASE IV.—(Hosp. No. 2076/22.) Woman, aged forty-five years. *Tumor of left breast,* eighteen months' duration, gradually increasing in size, loss of twenty-five pounds in weight since onset of tumor. Examination showed a hard, movable, slightly tender tumor mass in left breast. Provisional diagnosis fibroadenoma. Shortly after admission there was a sanguinopurulent discharge from the nipple and slight shooting pain in the breast. Right breast normal. At operation a small mass, size of hen's egg, was removed from the left breast. The pathological report read: Papilliferous cyst adenocarcinoma. The patient was lost sight of for a while but returned to the Follow-up Clinic in 1928, six years and six months after operation, presenting a recurrent nodule in the operated breast. The nodule was excised together with scar tissue. Pathological report: "Small cell, small alveolar carcinoma." The patient has been coming regularly to the Follow-up Clinic at intervals of four to six months, the last visit being January 10, 1930. She is perfectly well and able to support herself by laundry work.

In a recent study of end-results of carcinoma of the breast before the establishment of the follow-up system, now in the tenth year, we found that of 100 cases taken at random, covering a period of about fifteen years, 13 per cent. of the patients were living and well ten or more years after operation. It is only logical to suppose that the number is actually greater than thus appears, for the replies included a number of instances of death from intercurrent disease or accident of patients who had survived operation for periods varying from two to eight or more years without recurrence.

We are apt to think of cancer of the cervix or the fundus of the uterus as among the most hopeless ones, but still we have a number of five-year cures to our credit. Of a total of 140 cases treated by operation and radium, operation alone, or radium alone, eight are living and well from fifty to

eighty-one months, *i.e.*, four to seven years after treatment. Here, likewise, we must not lose sight of those dying from intercurrent disease or accident, so that the actual figures are somewhat better than indicated by the 8 per cent. of cures of almost five years or more. Time does not permit an analysis of these cases as to the type of tumor, duration of symptoms before coming for treatment and general constitutional features of the various patients. All of these naturally have an important bearing on prognosis. However, the conclusion to be drawn from the series of cases of cancer of the uterus or cervix or both from which these figures are taken is that in our experience surgery either alone or followed by the application of radium gives better results than radium alone, and that the earlier the cases come, the better the chance of a cure or at least a prolongation of life in comparative comfort. Our experience with radium and X-ray in the treatment of cancer has not by any means been encouraging. I do not refer to squamous-cell carcinoma. Again, I am forced to say that with a few exceptions neither radiation nor X-ray in the after treatment of operated patients has been as satisfactory as many claim. It seems strange that there is a great difference of opinion between gynæcologists, radium and X-ray specialists and the general surgeon on this point. My thought is that the general surgeon who has a large experience in the treatment of all forms of cancer in different parts of the body is the better judge. As an instance of prolongation of life after surgery, let me cite the following:

Case IV.—(Hosp. No. 2773/29.) Female, fifty-nine years of age. Was a patient in the Lankenau Hospital twenty years ago when a panhysterectomy was done for cancer of the fundus of the uterus. The patient remained well until six months before her present admission. At that time following, as she thought, strain of lifting, she developed a profuse yellowish vaginal discharge, and had lost fifteen pounds in weight in the past two years. The patient is a rather undernourished individual weighing 120 pounds. General health excellent. Appetite and digestion good. Physical examination entirely negative except the vagina which was small, and showed an erosion of the postero-superior wall, which bled easily on manipulation. Diagnosis of carcinoma of the vagina was made. Under gas-oxygen anæsthesia a tube of 50 milligrams of radium was placed crosswise in the upper part of the vagina and removed in twenty-four hours. This was done on October 28, 1929. When seen again December 10, the patient reported that there had been no discharge for several weeks after the radium treatment, but about two weeks ago there developed a watery yellowish discharge associated with pain low down in the abdomen on both sides. Otherwise, health is good. The patient was seen again on January 14. She then complained of backache and persistent yellowish discharge, more marked when moving about actively. Vaginal examination showed a perfectly smooth vagina. No further treatment indicated for the present.

Case V.—Another instance is Hosp. No. 74/22. Woman, aged forty-five years. In 1918 (two years prior to the establishment of the Follow-up System) the patient had a complete panhysterectomy. The pathological report of the specimens showed benign conditions except for a papilliferous cyst and mucoid degeneration of one ovary. The patient remained well for two and a half years. Then she developed lower abdominal pain, backache, shortness of breath, constipation and urinary frequency. With these complaints she came for readmission three years after operation. Physical examination showed abdominal fluid and a fluid wave that was transmitted on palpation. Laparotomy was done. About 2,000 cubic centimetres of blood-stained fluid and gelatinous material

were removed from the abdomen. A diagnosis of metastatic carcinoma of the peritoneum originating in the pelvis was made. The pathological report read: "Gelatinous material containing many small nodules shows mucoid carcinoma." The patient has been seen regularly since then at six months' intervals. Progress was satisfactory for forty-six months. At this time the abdomen was again distended with fluid. This was removed by tapping. Six months later a hard, globular mass was present in the abdomen, but there was no sign of fluid. She then had a course of X-ray treatment for a period of one year, at the end of which abdominal measurements showed slight increase in size of the mass. The patient, however, felt well and has continued so until the present time. When last seen, January 10, 1930, twelve years after the original operation and eight years after the laparotomy, she was well, except for weakness due to a recent attack of illness diagnosed as myalgia. The hard mass was still present in the abdomen but had not increased in size. Patient was in excellent spirits and up to her recent illness had been doing all her own housework.

Very satisfactory results can also be reported with many cases of intestinal cancer. In fact I have in mind several on whom I operated as long as from ten to seventeen years ago who have remained well. Among these is a physician living in Philadelphia, who at the time of operation, July, 1914, was fifty-nine years of age. He had a tumor of the ascending colon. I resected the terminal ileum, the cæcum and the ascending colon. Pathological report, adenocarcinoma. The doctor is in excellent health in spite of his seventy-five years, never having had the slightest symptoms since his operation. And I have just heard from a gentleman on whom I did a resection of the colon for carcinoma fourteen years ago. He is enjoying excellent health and at present is traveling in California. He was fifty-seven years old at the time of the operation.

CASE VI.—And here is a case of *cancer of the rectum* in a young woman, aged thirty-two years, on whom I did a Kraske operation in 1926, preserving the internal and external sphincter. I saw the patient two weeks ago and she is entirely free from any symptoms of recurrence. Her bowels move freely without cathartics, and she is perfectly well.

Of the numerous methods of treatment at our disposal only two have given definite results. The first and foremost is surgery; the second is by radiation with X-ray or radium, neither of which has done the good they are commonly said to do. I speak advisedly and with feeling, especially with regard to radium. The cures that I have cited are surgical cures. And the cures have not been because of grading the tumor or because they have had X-rays before, during and after the operation or because of other things to which men of little experience give attention, but because of good, radical surgery done early. Since we may acknowledge that our surgery as a whole is good and since unfortunately for progress in this direction, it is about as radical as can be done, our attention must therefore be directed to the "come early" part. Now in the skin, or the breast or sometimes in the uterus, the signs of cancer are fortunately early and fortunately too, can be recognized by the patients themselves. We are teaching them to do this. But in other situations, as for instance the stomach, where it is so common, the early signs are such as to baffle the most astute clinician; indeed I may say there

are no early signs which are not also the signs of other things. Here is one place where research is urgently needed—to find means of diagnosing early internal cancers. We must tell our colleagues, the clinicians and especially the research workers, about this again and again, repeat it, emphasize it, show them the results of late diagnosis and ask them to work with and for us and the good of the patients. Encourage the investigators, stimulate them, help them with their problems, remembering that without them, surgery would not be the blessing it is today. Theirs is not the spectacular part of the field: too often they are unsung, even laughed at, always underpaid and often underequipped. But remember Pasteur, Virchow, Ludwig, Koch, Kendall, MacLeod, Banting and all the others. How many patients snug and secure in hospitals know what is being done in the laboratories for their safety? Indeed, many patients do not know what a laboratory is, but think it is a place to wash your hands, a lavatory.

If, then, the only cures of cancer have come from surgery and a few from radiation, how many do we cure? Judging by reports, quite a few, but I pay little attention to them unless they come from individuals or institutions where there is a follow-up service. Unfortunately we have so few of these. I would add to this that a follow-up service must not only exist but must have a very important qualification. It must be hard-boiled. It must give no one, and no procedure the benefit of the doubt. It must not let enthusiasm influence facts. And the cold, hard facts must be the foundation and framework of its reports. Then and only then will we see how many cancer cases we cure in the average run that come to us.

For my next remarks it matters little exactly what the percentage of cures is. We all know that in spite of the encouraging examples just cited, it is still too low for our peace and comfort of mind and for the trust our patients should have in us. So the answer is quite obvious—new knowledge and new methods must be discovered and this can be done by research and research alone. We, as surgeons, can probably help by taking careful histories, records, and observations and by final summations. But the kernel of the nut is for the pathologists, physiologists, biologists, chemists and many others. Where and how shall they begin? It may be of interest to you to know what is being done along these lines in the Research Institute of the Lankenau Clinic under the able direction of Drs. Stanley P. Reimann and Frederick S. Hammett. With the kind permission of the Chairman, let me read a brief outline prepared by Doctor Reimann on the status of their work:

"Some two and a half years ago, the late lamented Mr. Rodman Wanamaker built a Research Institute for the Lankenau Hospital and supplied funds for a small nucleus of workers in cancer research. How did we begin? My first statement was, that the one and only factor common to all kinds of cancer is cell division; not just growth in size which is a different story, but growth in number of cells. Obviously, this is the place to begin. Since mitosis is a moving process in which chemical molecules are in active change,

our workers made it their task to find out what these changes were. Experiments were made with plants since they are easier for these experiments than animals, and it was discovered that in the roots of plants sulphur was present in the nuclei of cells in mitosis and then that the sulphur must be present in a certain form combined with hydrogen. The chemists call the group 'sulphydryl.' Then this same substance was found in animals. Now in cells which are not in mitosis, the sulphur is present in an altogether different form. If this is true, then cells should divide and grow in numbers if they are given sulphur in the sulphydryl arrangement. This was soon found to be so, and plants, minute animals such as paramecia, tissue cultures, the tissues of rats, mice and humans, all started to grow when they were fed, so to speak, on the sulphydryl compounds which our chemists had made. Already we have had a practical demonstration of the principle thus discovered, by the fact that a number of stubborn wounds such as leg ulcer and bed sores were stimulated to rapid healing by the use of the compounds. The compounds used and the details of their use will soon be published in the *Journal of the American Medical Association.*

Further experiments during the past few months gave overwhelming corroborating proof of these findings and now justify the unequivocal statement: normal cell division takes place because sulphydryl is formed, and never takes place unless it is present.

The next step is plain to everyone: find the substance which normally stops cell division. That there is such an antidote is perfectly apparent. Otherwise wounds would never stop healing. Indeed children would never stop growing. Just a few more divisions of the cells in an adult human being would make him as big as an elephant, whose cells are no larger than those of humans, so of course he must have more of them to account for his size.

Naturally enough, our interest now centers in sulphur. What do we know of it except we eat it mostly as cystin and excrete it as sulphates? There is a chemical study of the first magnitude ahead of us, the beginnings of which are just appearing in the literature.

Now the points which I want to drive home in any discussion of the curability of cancer can be summed up in a few sentences:

(1) Present methods are inadequate.

(2) Research must be done for the discovery of new things.

(3) The kind of research which at present promises the best hope is the chemistry of the body which normally starts, stops and controls cell division. Whether we are right or wrong in our theory that sulphur is the key to the lock, the chemical method of attack must be developed. Even if it is shown in the future that a micro-organism causes cancer, which seems extremely doubtful, that micro-organism must perforce do it by starting cell division. We must know the metabolic activities of an organism in growth and then try to change them. We can change the body chemistry of acids and bases,

we can change oxidation by thyroxin, sugar metabolism by insulin, why not the equilibrium of cell division?"

And for all this work endowment funds are essential.

In conclusion, let me again emphasize the importance of research work in this serious problem. Much has been accomplished but our methods are still more or less empiric. For example, we apply radium with considerable success in some cases and none in others. Some patients do well after operation; others do not. Some women develop lymphatic œdema of the arm; others do not. All these are questions that require elucidation and will probably not be explained until the cause of cancer is discovered. These questions require study and study, and more study. The work is time-consuming and money-consuming and I should like to say to those who have wealth at their disposal that money devoted to fostering the study of this vital question will prove of greater benefit than even the most far-reaching vision can foresee at this time. I hope a word to the wise and intelligent philanthropists in our midst is sufficient.

SPASMODIC TORTICOLLIS *

INTERRUPTION OF THE AFFERENT SYSTEM ALONE IN THE TREATMENT

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Spasmodic torticollis in its more aggravated form is one of the most distressing of physical ailments. Men are barred from public life and women are forced to lives of seclusion. Embarrassed always by the uncontrollable movements, they shun the streets, places of amusement, and social gatherings. It is well known that whenever attention is focused on the afflicted subject and whenever the subject is conscious of this, the movements are always aggravated. Probably no other infirmity of the body so effectively blocks the career of the afflicted or is a greater handicap to the enjoyment of life.

The time seems appropriate, therefore, that an effort be made to find a means of relief which will at once be effective and at the same time be accepted and approved by the profession. As we shall see, attempts have been made from time to time to control the spasm by surgical measures but up to the present one could hardly say there has been any generally accepted procedure. My interest in the subject has been aroused by the opportunity of operating within the past six months on four cases of spasmodic torticollis, an unusual number in this comparatively short period. And because the results of the method we have adopted seem promising, I venture to bring this subject to the attention of this meeting.

Since the days of the sixteenth century when the term "torticollis" was used first by the French physician, Rabelais, the clinical syndrome "spasmodic torticollis" has been a subject of dispute and discussion both as to its origin and its treatment. It would not be amiss, before discussing a means of surgical attack, to recall to mind some of the views maintained as to the causative mechanism of spastic conditions. As early as 1896, Anton [1] regarded chorea as being due to a deficient inhibitory mechanism in the nervous system, active on an extrapyramidal motor unit, and in 1897 Bonhöffer [1] claimed it to be a disturbance in regulation of afferent pathways. Stauffenberg [1] spoke of an extrapyramidal system, in which he included the frontal lobes, corpus striatum, thalamus, cerebellum and nucleus ruber.

We are not concerned in this discussion with spasmodic torticollis of peripheral origin or even with that of central origin, when the source of irritation may be in the cerebral cortex.

According to Foerster [2] by far the most common causes of spasmodic torticollis are lesions of the globus pallidus and corpus striatum. The extra-

* Read at the Joint Meeting of the Philadelphia Academy of Surgery and the New York Surgical Society, in Philadelphia, February 13, 1930.

pyramidal corticofugal pathways pass through the globus pallidus to the muscles. Interruption of them leads to the so-called "pallidum syndrome" with its characteristic disturbance of motility, among them a rigid torticollis. Affections of the corpus striatum may be congenital or may develop later in life on the basis of a hereditary predisposition. They give rise to spastic conditions known as "striatal hyperkinesis," to which belong chorea, athetosis, etc. Torticollis of striatal origin is characterized by a slow and irregular, intermittent cramp of the head rotators.

The corpus striatum serves as an inhibitory apparatus of the thalamo-pallidary reflex arch. There is an uninterrupted flow of impulses from all sensory receptors of the body to the thalamus opticus, and these impulses would all be returned to the periphery via the globus pallidus, were it not for the inhibitory action of the corpus striatum. A preëxisting deficiency for this inhibitory mechanism, Foerster believes, is necessary for the development of spasmodic torticollis of any type.

The plasticity of muscles that have to do with the maintenance of posture Sherrington [3] believes to be dependent upon the integrity of the dorsal roots and on the basis of this, the theory has been advanced that muscle tonus is a proprioceptive reflex. The sensory impulses from a given muscle are alone responsible for the plasticity of that muscle.

Sherrington states that in decerebrate rigidity the tonic rigidity of a muscle is maintained when all the nerves to the limb have been severed except the nerves of the muscle itself. The rigidity of the muscles immediately ceases on severance of the spinal afferent roots, through which pass the afferent fibres from the muscle. It was on the basis of this observation that McKenzie [4] in 1924 suggested that the muscle spasm of torticollis might be effectively relieved by section limited to the posterior roots.

To Ranson [5] we credit the most extensive research into the dorsal roots in relation to muscle tonus. He not only reviews the literature of the subject from some of the earliest observations but reports the results of his own experiments on cats; a series in which the leg was completely de-afferented by section of the dorsal roots close to the spinal cord, a series in which all the spinal ganglia associated with the right lumbosacral plexus were removed, and another series dealing with decerebrate animals. He summarizes his results by saying that in spite of the great theoretical and practical importance of the problem, and notwithstanding the large amount of work which has been done to elucidate it, the nature of the muscle tonus has not yet been determined nor has the rôle played by the dorsal roots in its maintenance been made clear. Two theories have been advanced in explanation of these; the proprioceptive reflex theory of Sherrington is the one generally accepted, but the theory of the antidromic conduction of tonic impulses in the dorsal roots has much in its favor and must be given careful consideration. There is no doubt that the plasticity which is responsible for the uniform stiffness and which causes the limb to hold a posture passively imposed upon it, is dependent

upon the integrity of the dorsal roots. According to the theory of muscle tonus that one holds, one can explain this spasticity as a steady reflex contraction called forth by afferent impulses from the tonic muscles themselves, or as due to special tonic reflexes traveling antidromically over dorsal roots.

If it be true then that plasticity or muscle tonus is under the control of the dorsal or afferent roots, and if it be true, as Foerster says, that the corpus striatum in health serves as an inhibitory apparatus, we are supplied at once with two physiological principles upon which to formulate a plan of operative attack.

I am well aware of the fact that there may be some cases of spasmodic torticollis that may be of a functional nature. It so happens that I have never seen a case of what I may call the major type that was effectively treated on this basis. In fact one of the patients in my series was treated for a period of six months on this plan. And I must confess we must acknowledge no means or methods by which one might be able to differentiate between a spasmodic torticollis with and one without an organic basis.

My first experience with the surgical treatment of spasmodic torticollis was many years ago, when in a series of cases I performed the operation as first described by Keen [6] in which one exposed and divided the first three cervical nerves at their points of exit from the spinal canal. The operation was a difficult anatomical dissection and the results, though not perfect, were accompanied by a decided improvement.

Foerster [7] in 1918 advocated section of the dorsal roots for the relief of spasticity alone on the assumption of the generally accepted theory that the dorsal roots control muscle tonus. In 1921 Finney advised section of the posterior branches of the motor roots of the first, second and third cervical segments. In 1924 McKenzie [4] recommended section of the posterior roots for spasmodic torticollis although in the case he reported both the anterior and dorsal roots were divided. In 1927 Sicard, Haguenau and Wallich [8] reported a case of painful choreo-athetosis in which the posterior roots from the fourth cervical to the second thoracic were divided. The results were said to be satisfactory in so far as they concerned the relief of the athetosis, but voluntary control of the arm was almost entirely lost. Finally in 1928 Foerster [2] proposed that after resection of a portion of the rim of the foramen magnum the first four cervical roots be divided.

In further defense of the rationale of the posterior root operation for spasmodic torticollis, reference might be made to the value of this procedure in Little's disease.

It has been said that division of a large number of dorsal roots causes a temporary depression of spinal cord function such as that following transection of the cord. This phenomenon has not been observed by the writer, though in a series of experiments in lower animals Brooks [9] observed a parallelism between cord transection and posterior rhizotomy.

Many muscles are concerned in the movements of spasmodic torticollis.

Their function and nerve supply should be fully understood. Foremost, of course, (1) the sternocleidomastoid which rotates the head toward the contralateral side while tilting it toward the homolateral side. As this muscle stands out conspicuously when in spasm and as the posture of the head consequent upon its contraction is characteristic, it is usually not a difficult matter to determine which of the two sternocleidomastoids is at fault. The muscle is supplied not always exclusively by the spinal accessory but sometimes receives additional fibres from the upper cervical nerves.

(2) The upper portion of the trapezius causes on contraction contralateral rotation and homolateral retraction, simultaneously pulling the shoulder upward. The trapezius always has a dual innervation from the cervical nerves and the spinal accessory.

(3) The splenius capitis and the splenius cervicis which with the semispinalis capitis and longissimus capitis cause homolateral tilting and contralateral rotation. These muscles receive their innervation from the four upper cervical nerves although the splenius capitis and cervicis and the longissimus receive additional branches from the lower cervical and even the upper thoracic nerves.

(4) Finally there is the deepest layer of muscles which after all are the most powerful rotators, to wit, the rectus capitis posticus major and minor, and especially the obliquus capitis inferior. These muscles are supplied in the main by the four upper cervical nerves.

I need not describe the movements that one sees in the form of spasmodic torticollis to which we are limiting our discussion. As a rule the movements vary in frequency and violence in different cases or in the same case at different times. You have all observed what seems like a large functional element. Certainly the movements are always more exaggerated when the patient is in public places, is more or less self-conscious and at times of fatigue or excitement.

Before the operation, if operation there be, is undertaken, one should identify the muscles at fault. This may seem to be devoid of difficulty but from experience I know this not to be the case. In fact, I have disagreed with my colleagues as to this question of laterality. It is well known that as a rule the sternocleidomastoid is affected on one side and the posterior group on the other. But this combination does not always prevail as in some cases the anterior and posterior group may be involved on the same side and in one of my cases the posterior group was involved on both sides.

When the movements are violent and the muscles deep-seated it is a matter of speculation often which muscles are in contraction, but I am inclined to believe that bilateral involvement of the posterior groups will be found more often than we have been wont to believe. As one group contracts more violently than the other, the head will assume the position caused by the contraction of the more powerful group.

Within the past six months four cases of spasmodic torticollis have passed

through the Neurosurgical Service of the University Hospital, two of these having come to the hospital primarily as the patients of my colleague, Dr. William G. Spiller. I shall include an abstract of but one of the four:

CASE REPORT—F. M. C., female, age thirty-eight years (File No. 17448), was referred to the Neurosurgical Service of the University Hospital, November 18, 1929, by Dr. J. C. Roe.

Twelve years ago the patient had a thyroidectomy. After this she noticed her head was twisted slightly to the left and that there was twitching of the muscles of the back of the neck. As time passed she found it became constantly more difficult to hold her head in the normal position. Whenever she becomes nervous or excited the movements are exaggerated and the patient is becoming more and more concerned about her appearance.

The patient is single, well nourished, without any evidence of organic disease or neurological disorder other than the muscle spasm.

Upon inspection one observes frequent jerking of the head during which the right sternocleidomastoid muscle and the posterior muscles on the left side are in rigid spasm. The chin is directed upward and to the left and the head is drawn back and inclined toward the left shoulder. *Diagnosis.*—Spasmodic torticollis. *Operation.*—Rhizotomy C. 2 and C. 3, left, and C. 1, C. 2 and C. 3, right. Colonic anæsthesia.

With the patient in the prone position, head flexed, through a vertical incision the occipital bone and the cervical spine were exposed. A circular section of the occipital bone, including the posterior rim of the foramen magnum, together with spinous processes and laminæ of the first three cervical vertebræ were removed. Upon incising the dura one observed on inspection an asymmetrical arrangement of the posterior roots. The roots on either side did not leave the cord at the same level. The first posterior root seen on the right side emerged from the cord at a higher level than the first on the left and so on down to the lowest of the field. Three roots were crushed on the right and two on the left. We planned to crush also the intraspinal portion of the spinal accessory nerve, but curiously enough, though a satisfactory exposure was secured by rotation of the cord and by traction on the dentate ligament, the spinal accessory root could not be seen. Accordingly the wound was closed with tier sutures.

Immediate result.—When the patient was discharged from the hospital she had been relieved of the muscle spasm.

In another of the series, two months after the operation I spent three hours with the patient and during the entire time, there were no deviations of the head and neck. In the third case, seen several months after the operation, there were no spasmodic contractures but the head was inclined somewhat to one side as though the posterior group of muscles on the affected side and perhaps the ligaments were shortened by the prolonged period of contraction. The fourth case was still in the hospital when this report went to press. The left spinal accessory nerve in this case was divided in the neck after the rhizotomy. When last examined the posterior muscles were entirely relaxed but there were still some contractions, though moderate, which could readily be traced to the right sternocleidomastoid muscle.

It is apparent from the trend of the discussion that my thoughts are directed toward an operation in which only the posterior or afferent roots are sectioned. I am entirely in accord with Foerster when he says that for all severe cases of what he calls "mobile spastic torticollis," in which a focal organic lesion of the neostriatum is at fault, operation, and operation alone, will afford relief. Those who with me have labored with the extravertebral resection of the first three cervical nerves will welcome a substitute. As

Foerster says the operation is an especially "*mühseliges*" experience and at best is not radical in effect. Hence the proposal to substitute an intra- for an extraspinal exposure is welcome.

Whether one divide the anterior or the posterior roots, or both, by the intradural method is a matter of little consequence from the standpoint of operative convenience and facility, but on the basis of physiological evidence one feels justified in recommending the section of only the posterior roots and the question at once arises as to the number of roots to be divided and whether on one or both sides. The first, second and third must be rendered functionless. One hesitates because of its relation to the diaphragm to disturb either the afferent or efferent pathways of the fourth cervical segment. Should we go further and crush or section the fifth, sixth, seventh, or eighth roots? Even though some of the muscles involved, especially the splenius capitis and cervicis and the longissimus, are supplied by the lower cervical and upper thoracic roots one questions the propriety of interrupting the sensory supply to the upper extremity. One must, therefore, be content to restrict one's attack to the first three cervical roots, whether on one or both sides depends upon whether the posterior group is involved on one or both sides. In some cases there is a reasonable doubt and as a matter of fact in the four cases which form the basis of this report I included the roots of both sides in the operative program.

No matter what the plan of procedure with reference to the cervical roots, every operation for the control of spasmodic torticollis must include severance of the spinal accessory nerve. Usually one can readily see the spinal portion of the spinal accessory nerve in the cervical canal and divide it there.

Little need be said as to the operative technic itself. To one accustomed to laminectomies of the upper cervical canal for the exposure of spinal cord tumors, the operative steps are familiar. I have found it especially convenient before attempting the laminectomy first to rongeur away a centimetre of bone from the posterior margin of the foramen magnum. This renders the first lamina much more accessible and facilitates the removal of spinous processes and laminæ of both the atlas and axis. For this operation the position of the patient is precisely that employed in the suboccipital craniectomy.

Once the dura is incised the posterior roots are readily seen. Whether one cuts or crushes or ligates the root is a matter of individual preference. Personally I prefer always to crush the root with artery clamp or a ligature of arterial silk, because when one cuts the posterior roots one may cut a tiny artery accompanying it and a few drops of blood may soil the operative field.

After the roots have been crushed one turns one's attention to the spinal portion of the spinal accessory nerve. For its exposure one must rotate the cord by gentle traction on a dentate ligament. In one of my cases I failed to see the structure in question. Under such circumstances one may always at the same or another sitting expose the nerve in the posterior triangle of the neck. To attempt division of the spinal accessory nerve in the posterior

fossa before its exit from the skull would add an unnecessary hazard to the operation and might lead to complications from injury to adjacent nerves.

After all, any operation for the relief of "spasmodic torticollis" must be regarded as an operation of choice and not one of necessity, since the disease itself has no disastrous effects or fatal tendencies. Hence any proposal of relief by operation must of itself be devoid of risk. The operation recommended may be so classified. In none of the four cases of this series were there any complications and convalescence in all was uninterrupted.

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THE BACTERIOPHAGE IN SURGERY

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The antiseptic method of treating infected wounds reached its culmination during and after the late war when the Carrel-Dakin technic was perfected. The wound was irrigated frequently with a solution combining high germicidal power with low toxicity for the tissues. When the wound was complicated by fracture or loss of bony substance due to trauma or infection, the treatment consisted necessarily of two stages; disinfection, and repair of the bone lesion. Attempts to combine the two necessitated splinting, commonly with plaster, with provision for carrying on the frequent irrigations through tubes that coursed over the infected and granulating surfaces of the bony fragments. This was not only an arduous routine, distressing to both surgeon and patient, but was associated with risk of reinfection. Indeed there was no certainty that reinfection was not being induced today by the very technic that would be used to combat it tomorrow. The method had many other objections, such as the irritation of the skin by the seepage and subsequent evaporation and concentration of the irrigating fluid under the case. The fluid also penetrated and softened the case about the window, so that the area left unsupported constantly increased. Not only was displacement of underlying fracture fragments thus favored, but the protruding soft tissues became œdematous and unfavorable to healing as well as favorable to infection. In many cases these objections debarred one from the use of plaster altogether. With all these drawbacks, the Carrel-Dakin was undoubtedly the most successful method of treatment up to that time, and it could not be criticized in the face of the results that were achieved.

With more sober judgment as the rush of war surgery abated, these objections gained more weight and the pendulum suddenly swung the other way when Orr proposed a method which was the absolute antithesis: for antiseptics he substituted a dressing without germicidal power; instead of perpetual interference, he proposed to let the wound alone for weeks. It was for the treatment of osteomyelitis that Orr proposed his revolutionary method, but it has since been applied to other infective lesions of bones and even to lesions where bone is not involved.

Orr [4] emphasizes four steps in the treatment: (1) primary asepsis or antisepsis to reduce the focal infection; (2) adequate drainage; (3) a postoperative dressing that will protect the wound against reinfection; (4) immobilization, so that movement, pain and muscle spasm are entirely relieved; and with all the parts in correct position for recovery.

With the soundness of these principles one must agree. Undoubtedly

anything that promotes healing enhances local resistance to infection not only by promoting the removal of débris but by bringing to the infected zone all the resources of the blood, both cellular and humoral.

Operative Technic.—The extent of the lesion having first been determined from the X-ray, a suitable incision is made for its eventual complete exposure. The site of the incision varies with the circumstances. Generally speaking, it is desirable to approach the bone where it is most superficial. If the incision from previous operation has not healed or healed well, or if a sinus persists there or elsewhere, it is better, when possible, to include such infected tissue in the incision so that scar tissue and necrotic tissue may be trimmed away. If there are scattered sinuses the incision may include one or more; the others are curetted. When an incision is meant to include a sinus, a forceps is first inserted into the sinus to determine its direction and to serve as a guide for the incision. If there is a point of special tenderness or an area of fluctuation, the incision is made over it, if possible. The incision is always made in the long axis of the limb, and is never carried through a muscle group, such as the quadriceps. The mesial side of the thigh is avoided for obvious reasons. It is preferable to follow the general line of cleavage between muscle groups, but one never attempts to dissect the muscles or to follow a fascial plane precisely; a sharp, clean and rapid incision carried immediately to the bone is preferable. If there are any sequestra they are removed. The periosteum is not reflected but is incised around the area to be removed. One may use the single motor-saw, but, as a rule, the osteotome is more practicable. Sufficient bone is removed to uncover the entire lesion as exposure reveals its extent. The primary bone incision is carried beyond the line of demarcation of affected bone, and if any necrotic bone still remains that is chiseled off back into healthy tissue. All sequestra are removed and overhanging ledges trimmed until the margins have a shelving contour best described by the term "saucerized." As healing eventually occurs, the contraction of cicatrization draws the soft tissues into close contact with the bone. From this source, the bone derives additional circulation and its healing, growth and reconstruction are thus aided. Pus and necrotic tissue are swabbed out and the wound cleansed with dry gauze.

Orr's technic was formerly followed at this point and the wound swabbed with iodine and 95 per cent. alcohol. Various considerations have weighed against the use of antispetics: it is impossible to sterilize a wound with germicides applied for so brief a time; such powerful agents as iodine and concentrated alcohol damage the tissues and provide a nidus for proliferation of such infecting organisms as escape the antiseptic; the care in providing a fresh surface of healthy bone is thus rendered largely futile, since the wound is now bounded by an immediate layer of coagulated blood, and damaged, if not dead, cellular structures in bone and muscle; between healthy tissue and infection there thus lies a dead layer, of microscopic thickness no doubt, which both favors the infection and hinders the exudation of serum and the migration of leucocytes, and must be removed before

the infection is submitted to the full force of the defensive reactions of the body. These arguments against the use of germicides in wounds generally are not new, and they have not been generally accepted. A much more cogent argument against the use of antiseptics developed from the investigations reported in this paper. It will be presented with the discussion of these investigations.

When saucerization and cleansing are completed, the wound is packed with vaseline and vaseline gauze soaked in an excess of sterile yellow vaseline. Since this dressing is semi-fluid at body temperature, it can be readily insinuated into the most remote corners. The packing is allowed to overflow the wound so that it covers an inch or more of skin on either side. It is then well covered with padding, after which the limb is incased in plaster and the joints above and below thus immobilized. No window is left. The dressing is left intact for eight to ten weeks, at which time it is entirely changed and reapplied after simple cleansing, unless the wound is entirely healed. The wound is dressed again as before and left for a similar period. This is repeated until healing is complete. Sometimes the plaster is omitted if healing is well advanced.

Comment.—The Orr dressing would appear, at first glance, like putting an effective stopper in the wound. However much it may seem to violate the traditions of free drainage, there is no doubt that drainage is adequate. When the plaster is removed at the end of six or eight weeks, the dressings are often saturated and the limb bathed in pus, which is usually extremely fetid. Drainage is at least free enough to release tension and thus to free the affected tissues from the excessive pressure that would not only promote absorption of toxins but prevent the free circulation of blood and lymph to the lesion which is necessary for sterilization of the wound and repair of structures.

The most striking characteristic of the wound is the appearance of the granulations. They have none of the gray unhealthy appearance commonly manifested by granulations; instead, they are of glistening red color; they are not exuberant or œdematous. They impress one as granulations pursuing a normal uninterrupted course under the most favorable circumstances. By comparing the conditions under which such granulations grow with those present when the wound is dressed by other methods, one gains an inkling of the nature of these favorable circumstances. Growth in the body, whether normal growth of tissues or repair or replacement of structures, takes place under the mutual pressure of tissues. The permeation of tissues by blood and lymph is normally regulated in accordance with this pressure. It is reasonable to assume that, when a tissue is relieved of the counterpressure of neighboring tissues, this balance, both circulatory and osmotic, is upset. The severed tissue must tend to become hyperæmic and œdematous. The overnutrition and sluggish drainage result in exuberant, unhealthy granulation tissue. When the wound is well packed with vaseline gauze and enclosed in a dressing surrounded by plaster, so that pressure is uniform over the

wound and the surrounding structures, the normal appearance of the resulting granulations suggests that normal physiological pressure has been restored by the dressing. Indeed, the pus is expressed and the packing extruded from the wound by the pressure of the growing tissues. The point at which this equilibrium is maintained by this dressing is apparently that which is optimal for healing tissues. The speed of epithelialization and the rapid assumption of a normal appearance by the new skin suggests that the healing of all structures is greatly favored by the equalization of pressure at an optimal level. This principle may be applied to the treatment of varicose ulcers since it is presumably this mechanism which explains the rapid and satisfactory healing of these lesions when the vaseline and plaster dressing is used.

The influence of infection and inflammation on the health of granulations must not be overlooked. The normal circulatory response to injury is hyperæmia and œdema which undoubtedly contribute to the unhealthy overgrowth of granulations. There must be, then, some other factor besides counterpressure to account for the condition of the granulations. It has been suggested by one of us (F. H. A.[1]) that some principle is retained in the wound, by this method of dressing, which will, if undisturbed, contribute materially to the destruction of the infecting organisms. It is probable that this consists in part of the antibodies and living phagocytes; but the further suggestion was made that the specific bacteriophage accumulated in the wound if it was not dissipated too rapidly by drainage, irrigation and frequent dressing. There are thus two causes which may be suggested for the phenomenal results produced by this new method of dressing: one is mechanical and physiological, the other is concerned with those newer principles in bacteriology which have to do with the nature and action of the bacteriophage.

The work which we have conducted since the original suggestion was undertaken to discover whether a bacteriophage can be demonstrated in the wound after it has been enclosed in an Orr dressing for some weeks, whether such bacteriophage is specific for any of the infecting organisms, and whether and to what extent the character of that organism is changed in the presence of the bacteriophage.

Upwards of 100 cases have been treated by the closed method since it was begun nearly three years ago. The bacteriological investigation has covered about a year.

Bacteriological Procedure.—Pus obtained from the wound at operation or at subsequent change of plaster dressing was sent to the laboratory for cultural examination. The viable bacterial flora were determined and a record made of the relative numerical predominance of the organisms present. The strains occurring in largest numbers were thought to be of some etiological significance, or secondary invaders with which in chronic osteomyelitis the host must cope for long periods of time and were, therefore, worthy of study. In a search for the presence of a lytic agent which might

account for the clean appearance of wounds treated by the Orr method, it was first necessary to determine the suceptibility or resistance of these strains of bacteria to lytic action. This was done by subjecting them to the action of suitable stock races of bacteriophage of high titre. The fermentative reactions of organisms under study were determined at each examination as one means of identifying the same strain or of ascertaining biochemical changes which might be brought about by environmental conditions in the wound. Broth cultures of the wound pus after twenty-four hours' incubation were filtered through Berkefeld N filters and these bacteria-free filtrates tested for the presence of native bacteriophage. Since d'Herelle [2] has shown that strong lytic principles isolated from the human intestine in health and disease may show action against few or many of the bacteria constituting the flora, known susceptible strains of the species corresponding to those present in the wounds were employed in addition to the wound strains in an effort to demonstrate readily the presence of lytic agents in these filtrates.

CASE I.—The patient, aged ten years, was admitted to the orthopædic service with a diagnosis of chronic multiple osteomyelitis. The infection was apparently hæmatogenous. Two operations had been performed within the previous year at another hospital. After admission to this service sequestrectomy of both tibiæ was done and an abscess of the right heel was incised and drained. Eight weeks later when the condition of the patient warranted further surgical intervention, sequestrectomy was done upon the left humerus which had shown draining sinuses for nearly a year. In each instance the Orr technic was employed in treatment. The three wounds were studied and the bacterial flora compared at every subsequent change of dressing.

Right Tibia.—Cultures from the wound at operation showed hæmolytic Staphylococcus aureus to be the predominating organism, with B. coli (acidi lactici) present in fewer numbers. This staphylococcus was not a lysogenic strain, but was susceptible to lysis by four stock races of anti-staphylococcus bacteriophage, while the strain of B. coli was lysed by two of the thirteen races of anti-coli bacteriophage to which it was subjected. The filtrate of a broth culture of the pus from the wound showed the presence of a native bacteriophage which when first isolated was active against two stock strains of B. coli known to be susceptible to lysis. After having been exalted with one of these by the usual method of serial passages, feeding and filtering for six generations, a titre of 1 times 10^{-9} was reached. It was interesting then to determine whether this bacteriophage present in the filtered culture from the wound was also capable of bringing about lysis of the strain of B. coli associated with it in the lesion. After five serial passages with this bacillus complete lysis was obtained with a titre of 1 times 10^{-8}. It was impossible to demonstrate a lytic principle in the filtrate which showed any action upon either the hæmolytic Staphylococcus aureus present in the wound or against three stock strains of Staphylococcus aureus known to be susceptible to lysis.

After an interval of seven weeks, when the dressing was changed, the size of the wound, which at operation measured 11.5 centimetres long by 4 centimetres wide, was now reduced to 7.5 times 2.5 centimetres. A moderately fetid odor was observed; the skin about the wound showed no irritation and healthy granulations of a red color evidenced satisfactory healing. At this time B. coli (acidi lactici) was found to be the predominating organism. Hæmolytic Staphylococcus aureus present at operation was not recovered. B. pyocyaneus was present in small numbers. From the filtrate of the broth culture obtained at this time an anti-colic bacteriophage was again isolated which was active against the same stock strain of susceptible B. coli as was employed in the

first examination. Enhanced with this strain to a titre of 1 times 10^{-8}, the principle after six serial passages now showed no activity against the wound strain of B. coli recovered at this time, although this organism was lysed to the same degree by the same stock races of anti-coli bacteriophage as were employed at the first examination to determine the susceptibility of the strain to lysis. Four weeks later at the third examination and second change of plaster dressing the wound measured 6.5 times 2 centimetres and showed firm granulation tissue. Diphtheroids were now the predominating organism, while B. coli (acidi lactici) had dropped to second place; B. pyocyaneus was still present in small numbers. The strain of B. coli again gave the same fer-

TABLE I

CASE I.—*Chronic Multiple Osteomyelitis*

Right Tibia	*Left Tibia*	*Left Humerus*
First specimen Sept. 9 Hæmol. Staph. aureus* B. coli and Active Native anti-coli phage	Culture not obtained	
		First specimen Nov. 7 Hæmol. Staph. aureus Phage not detected
Second specimen Nov. 11 B. coli B. pyocyaneus Native anti-coli phage	First specimen Nov. 11 Non-hæmol. Staph. aureus Hæmol. Staph. aureus B. coli, B. pyocyaneus Native anti-coli phage	
Third specimen Dec. 9 Diphtheroids B. coli B. pyocyaneus Phage not detected	Second specimen Dec. 9 B. pyocyaneus Diphtheroids Phage not detected	Second specimen Dec. 9 Diphtheroids Hæmol. Staph. aureus Stock anti-staphylococcus Phage introduced
Fourth specimen Dec. 23 B. coli B. pyocyaneus Hæmol. Staph. aureus Phage not detected Wound ¼ area of Sept. 9	Dec. 23 Wound healed	Third specimen Dec. 23 Diphtheroids Hæmol. Staph. aureus Anti-staph. phage recovered from scrapings Wound healed

* Organisms are listed in the order of their predominance in the wound.

mentative reactions and was susceptible to lysis by the same stock races of anti-coli bacteriophage against which it had been previously tested. No native bacteriophage could be recovered at this time. One is mindful, however, that inability to demonstrate the lytic principle *in vitro* does not exclude its presence *in vivo*.

After another interval of two weeks, at the fourth examination and the third change of dressing the wound had decreased in size to 5 times 1.5 centimetres and showed beginning epithelization. Cultures showed B. coli (acidi lactici) predominating, B. pyocyaneus also present and the appearance (which may have been the reappearance) of a few colonies of hæmolytic. Straphylococcus aureus. Both the B. coli and the staphylococcus were susceptible to the stock races of bacteriophage active against them in the beginning. No native bacteriophage could be demonstrated at this examination. At the fourth dressing the wound had granulated in to approximately one-quarter the size of the original incision and showed marked new epithelialization.

It is interesting to note that from the first cultural examination of this wound a bacteriophage was isolated which was active against a stock-susceptible strain of B. coli and by the use of this the titre of this lytic principle was increased. The bacteriophage thus exalted was able to cause c. ıplete lysis of the wound strain of B. coli. At the second examination a bacteriophage was again isolated which was active against the same stock-susceptible strain of B. coli and was regenerated by it. However, this regenerated principle now showed no action upon the wound strain of B. coli. The third and fourth examinations revealed no bacteriophage at all. One may infer that in the interval of seven weeks the organism had undergone some change which at this time enabled it to resist *in vitro* the action of the native bacteriophage still present in the wound, although it was capable of being completely lysed by the stock races of bacteriophage to which it was susceptible in the beginning. It cannot be said, therefore, that the strain was resistant in a general sense, but rather that it had acquired some specific resistance to the native bacteriophage.

Left Tibia.—Although the right and left tibiæ were operated upon at the same time, the specimen from the left tibia was lost and unfortunately cultural examination was therefore deferred until the first change of plaster dressing seven weeks later. Here again the size of the incision was reduced from 8 times 2.5 centimetres at operation to 2.5 times 0.75 centimetres at this time. Healthy granulations were filling the wound and extensive epithelization was taking place. No œdema or skin irritation was noted. The following organisms constituted the wound flora at that time and are given in the order of their numerical predominance: non-hæmolytic Staphylococcus aureus, hæmolytic Staphylococcus aureus, B. coli (acidi lactici), B. pyocyaneus. The broth filtrate contained a bacteriophage active against a stock-sensitive strain of B. coli which, when exalted to a titre of 1 times 10^{-7}, was not, however, lytic for the B. coli from this wound. No lytic principle could be recovered which showed any action against the strains of Staphylococcus in the wound; neither did the native anti-coli bacteriophage have any action upon them, although they in themselves were susceptible to lysis by stock anti-staphylococcus bacteriophages.

One month later, at change of plaster dressing, the wound was completely covered with new epithelium and healed. While surface scrapings only were available for culture, it is worthy of note that both the staphylococcus and B. coli had disappeared and only B. pyocyaneus and diphtheroids remained, possible surface residents.

Humerus.—Seven weeks after the operations upon both tibiæ sequestrectomy of the left humerus was performed. The wound measured 9 times 4 centimetres. Cultures showed only few colonies of hæmolytic Staphylococcus aureus which were proven to be susceptible to lysis. No native bacteriophage could be recovered from this wound at this time or at any subsequent examination. At first change of dressing the picture presented here was in marked contrast to those of the right and left tibiæ. The skin was markedly irritated, being reddened and excoriated. Granulations were of a grayish-pink color and somewhat œdematous. Although there was a moderate amount of thin pus present, there was only slight wound odor. Since no native bacteriophage could be demonstrated, it was determined to employ as a therapeutic agent at this time a stock bacteriophage to which this wound organism had been proven susceptible when first isolated. That such an organism might during an interval of one month have become resistant, was a possibility. However, the staphylococcus isolated from a culture taken before the bacteriophage was introduced into the wound was still capable of being completely lysed by the bacteriophage used in the treatment. Two weeks later the wound was covered with new epithelium and the skin appeared normal. A swab culture of the surface area revealed a few colonies of hæmolytic Staphylococcus aureus and many diphtheroids. A filtrate of this culture showed an anti-staphylococcus bacteriophage which we assumed was the principle introduced at the previous dressing.

This case would seem to suggest that at the time of operation the recovered lytic principle is active against the organism of the corresponding species present in the wound, but that at subsequent examinations the organism, which we assume to be the same strain reappearing, has acquired some form of resistance to the bacteriophage with which it has been associated. That it lingers in the wound up to the time of complete healing with unaltered pathogenicity has not been proven by experiments to determine comparatively its pathogenicity at different stages of healing; but in the light of such a wholly satisfactory clinical result it may be inferred that either the pathogenicity of the organism for this host has been lost or that tissues have acquired greater resistance to such bacterial virulence than they had originally.

CASE II.—The patient was a woman aged twenty-one years. Two months previously she had been hurt in an automobile accident which resulted in a compound comminuted fracture of the left radius and ulna. On admission to this hospital bone fragments were projecting through the wound, and there was sloughing of the tissues on the volar and dorsal aspects of the forearm with osteomyelitis of the radius and ulna. Sequestrectomy was done, with application of the Orr technic. The wounds contained much pus; the dorsal incision was 10 times 5 centimetres while that on the volar aspect was somewhat larger, measuring 14 times 5 centimetres.

Cultures from pus removed at operation showed B. coli (acidi lactici) predominating and a few Staphylococcus aureus, both organisms being susceptible to lysis. A filtrate of the broth culture yielded an anti-staphylococcus bacteriophage which had a lytic exponent of -8 when exalted with a stock-susceptible strain of Staphylococcus aureus and was then able completely to lyse the Staphylococcus aureus of the wound. On the other hand the original broth filtrate was negative for lytic principle when carried by serial passage for six generations with the Staphylococcus aureus and B. coli of the wound.

After seven weeks, at the second examination and first change of plaster dressing both incisions had become smaller, the dorsal wound measuring 6.5 times 2.5 centimetres and showing some new epithelium, the volar aspect approximating 11 times 4 centimetres. In each instance the granulations were healthy and red and there was no skin irritation and very little fetid odor. Clinically, the picture was that of a healthy granulating wound. The same organisms were encountered, Staphylococcus aureus this time predominating. No bacteriophage could be recovered, although the strain of staphylococcus from the wound was still susceptible to lysis by the regenerated native anti-staphylococcus bacteriophage isolated at the first examination.

After another interval of seven weeks Staphylococcus aureus was the only organism present; the strain of B. coli having disappeared. Here again no lytic principle could be isolated.

The wound on the dorsal aspect of the forearm was healed and, since the volar aspect measured only 7.5 times 2.5 centimetres and showed a marked amount of new epithelium, the plaster dressing was discarded and replaced by the vaseline gauze dressing.

Four weeks later healing was complete.

CASE III.—The patient, aged forty years, was admitted to the hospital with a diagnosis of osteomyelitis of the left tibia of thirty-six years' duration. Two previous operations were unsuccessful and had left a draining sinus. Saucerization was done and an Orr dressing applied.

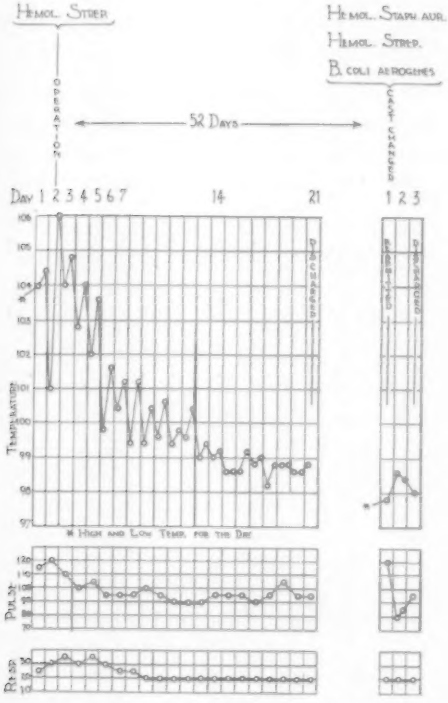
Cultural examination of pus from the wound showed hæmolytic Staphylococcus aureus predominating with a few diphtheroids present. From the broth filtrate an anti-staphylococcus bacteriophage was isolated which was active against a stock-susceptible strain of staphylococcus with a lytic exponent of -9. Here again the exalted

principle was lytic for the wound staphylococcus, though the broth filtrate showed no lytic agent capable of acting upon it directly without having been regenerated.

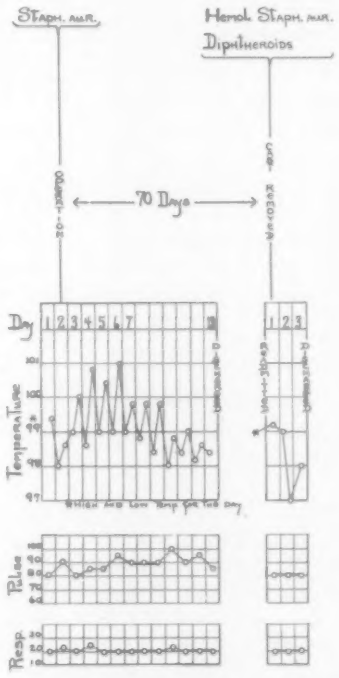
Later, at the first and second changes of plaster dressing, diphtheroids predominated, only a few colonies of hæmolytic Staphylococcus aureus being present. It was not possible again to recover a lytic principle from this case.

At the third examination, when the wound was granulating in satisfactorily and marked epithelization was taking place, a vaseline gauze dressing was substituted for the plaster.

CASE IV (Graph 1).—The patient, aged twenty-one years, was admitted to the orthopædic service with a history of fracture of the right ankle seven months previously for which four operations had been performed elsewhere. He was progressing well



GRAPH 1.—(Case IV.) A case of infection with Streptococcus hæmolyticus showing lysis of the high temperature.



GRAPH 2.—(Case V.)—A case of infection with Staphylococcus aureus showing how the reaction in temperature (and in general condition) may not be immediately favorable.

until a week prior to admittance when the ankle became swollen and tender. A diagnosis of acute osteomyelitis of astragalus and scaphoid of the right foot was made. Incision and drainage with Orr treatment was performed. At this time the temperature rose to 106 degrees F. A blood transfusion of 500 cubic centimetres was given the same day and, with only the usual post-operative care, the temperature receded gradually. Cultures made from material removed at operation showed the presence of a single infecting organism, Streptococcus hæmolyticus. During the period of fifty-two days following operation no complications developed. At the first change of cast the wound was granulating satisfactorily and the organisms present in the order of their predominance were hæmolytic Staphylococcus aureus, Streptococcus hæmolyticus and B. coli ærogenes. Four weeks after the operation, when the dressing was removed the second time, the wound was found completely healed.

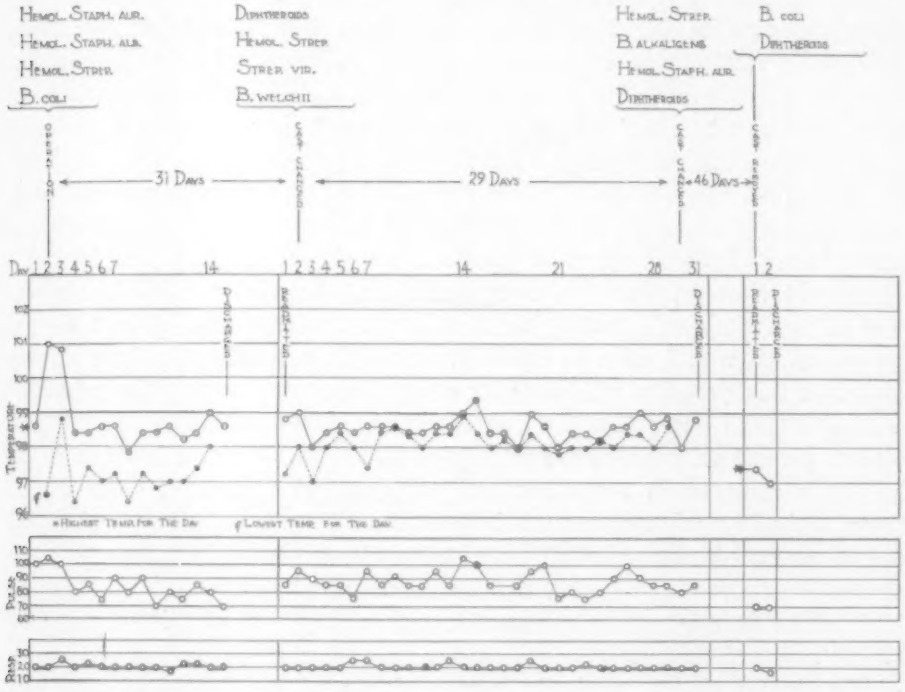
In this instance, as well as in four other cases of chronic osteomyelitis treated by the same method in which Streptococcus hæmolyticus was the single infecting organism or predominating in a mixed flora, there was evidence of the existence of streptococcus bacteriophage of a low order apparently similar to that described by Dutton.[3] Filtrates of wound pus showed action upon a stock-susceptible strain of Streptococcus hæmolyticus but clearing lasted only for from three to six hours at 37° C. and was then followed by secondary growth. Due to the tendency of streptococcus to dissociate rapidly in fluid medium at the optimal P_H for phage action, difficulties were encountered in an effort to raise the titre of these principles. An attempt to "train" bacterial strains to regenerate these principles was made by employing the technic described by Schwartzman.[5] In each instance after fifteen passages of the organisms through the phages the apparent increase in titre was slight. The significance of such weak lytic principles in the healing of streptococcus-infected wounds requires further detailed bacteriological study, but their occurrence in lesions of this type is recorded with due regard for the fact that conditions in the wound may provide necessary factors for the completion of processes which are by present technic only partially demonstrable *in vitro*.

The presence of hæmolytic streptococcus infection and a high temperature in this case might be considered a weighty argument against what seems like sealing up the infection. The effect of the operation is indicated in the graph; the general condition paralleled the temperature curve. It may eventuate that a high temperature with streptococcic infection will be considered an added indication for this type of operation.

CASE V. (Graph 2).—The patient, aged thirty-eight years, gave a history of fracture of humerus two years previously. Bone graft was attempted at another hospital but was followed by non-union, and infection occurred leaving a draining sinus which had been treated by the Carrel-Dakin method. Upon admittance to this hospital a diagnosis of osteomyelitis of left humerus following an onlay bone graft was made. Sequestrectomy was done and an Orr dressing applied. This wound also showed only one infecting organism, Staphylococcus aureus. Although the temperature did not at any time exceed 101° F., it was not until after the sixth day that it began to subside. The not uncommon observation in this treatment, that the temperature may not subside for several days following the operation, has been previously reported by one of us (F. H. A.[1]). The plaster dressing was removed after seventy days. At this time the cultures showed a hæmolytic strain of Staphylococcus aureus and diphtheroids, and the wound was granulating in satisfactorily. At the second subsequent change of dressing four months later, the wound was found healed. Two months later an inlay was inserted. There was no recrudescence of infection and union of the graft was solid after two months had elapsed. This affords striking proof of the satisfactory and permanent disappearance of the infection under this method of treatment.

CASE VI (Graph 3).—The patient, aged twenty-years, was admitted to the hospital with a previous history of injury to the left thigh, several operations having been performed elsewhere, which resulted in a draining sinus in the left leg of two years' duration. A diagnosis of chronic osteomyelitis of the lower two-thirds of the femur was made and sequestrectomy performed, followed by Orr treatment. Hæmolytic Staphylococcus aureus and albus, Streptococcus hæmolyticus and B. coli constituted the mixed

flora at operation. Thirty-one days later at change of the plaster dressing three swabs obtained from different areas of the wound were sent to the laboratory. Cultures from each of these showed diphtheroids, Streptococcus hæmolyticus, Streptococcus viridans and B. welchii. One hundred cubic centimetres of mixed welchii and tetanus antitoxin were administered upon receipt of the cultural findings and the cast was allowed to remain as usual. No change was noted in temperature, pulse or respiration and the patient made no special complaint. After twenty-nine days, at second change of plaster dressing, cultures were negative for B. welchii; the changes in the flora may be seen by the graph. Following an interval of forty-six days the plaster dressing was removed and a gauze dressing applied since the wound was almost covered with epithelium, and so nearly healed that the patient was told he need not return unless there was further trouble. This was three and a half months after the operation.



Graph 3.—(Case VI.) Mixed infection (including B. welchii), indicating the slight systemic response to the presence of an organism generally considered highly virulent, and in this case fatal to a guinea pig.

Three other such cases of mixed infection in which B. welchii was recovered from the wound either at operation or at subsequent change of dressing have been studied. In each instance there was a history of compound fracture resulting from an accident, or of chronic wounds previously subjected to one or more operations. In Case VI a possible explanation is the occurrence in the tissues of spores of an attenuated strain of B. welchii, lying dormant since the time of the accident or previous incision. Unfortunately no test was made to determine the pathogenicity of this strain. To save confusion, no reference to the presence of B. welchii was made in the presentation of Case II. It was found not only at the time of operation but at the first subsequent change of dressing. One cubic centimetre of the

twenty-four-hour mixed broth culture obtained at the time of operation was injected intramuscularly into a 400-gram guinea pig, causing death in twenty-two hours with marked hæmorrhagic gelatinous œdema, characteristic of toxic strains of B. welchii. Mixed antitoxin was administered to the patient, but here again the plaster dressing was allowed to remain and no untoward symptoms ensued. Cultures obtained at the first change of dressing showed B. welchii, which in a mixed broth culture again caused the death of a guinea pig in the same number of hours; thus no loss in virulence was indicated. It is evident that although this strain of B. welchii might be considered pathogenic by animal test, the host was able to tolerate or overcome it, since it was not recovered from the wound subsequently and no untoward symptoms were manifested. That spore-bearing anaërobes probably occur in many types of wounds more frequently than we realize may be due to the fact that no search is made for them, or that, as in these instances, through some protective mechanism the host is able under certain conditions to tolerate them, and no clinical evidence of their presence appears.

It will be recalled that the wound in Case II contained also an anti-staphylococcus phage and, since filtrates from Case VI as well as the other cases in which B. welchii was present showed anti-streptococcus bacteriophage of low order, there is the suggestion that these lytic principles may be one of the many contributing factors in the complex environment of the wound which would seem to establish an amicable relationship between the host and this parasite, which under other circumstances may be regarded with alarm. In Cases II and VI antitoxin was administered, but, since there was no clinical evidence of the activity of B. welchii, it was decided to withhold this measure in the other two cases, which, however, went on to complete healing without untoward symptoms. We are far from suggesting that B. welchii is not to be taken seriously. Its presence, in traumatic cases at least, must continue to call for immediate measures. The difference in its behavior in these chronic cases is noted largely because of the scientific interest.

Two cases similar clinically, one having a single infecting organism, Staphylococcus aureus, and the other an initial mixed flora of Streptococcus hæmolyticus and Staphylococcus aureus, were studied carefully by the same technic for the presence of bacteriophage. No lytic principle was recovered, however, either at the time of operation or upon subsequent cultural examination.

In ten cases in which no search was made for lytic principle, data are available for study of the wound flora and the relative predominance of the organisms at varying intervals through the period of treatment.

It must be borne in mind that material sent to the laboratory for study may not be taken in each instance from the same area of the wound, and data may thus be seemingly contradictory. As the gradual loss in virulence of the infectiny organism for the host proceeds, secondary invaders may appear in larger numbers proportionately. Again secondary invaders derived

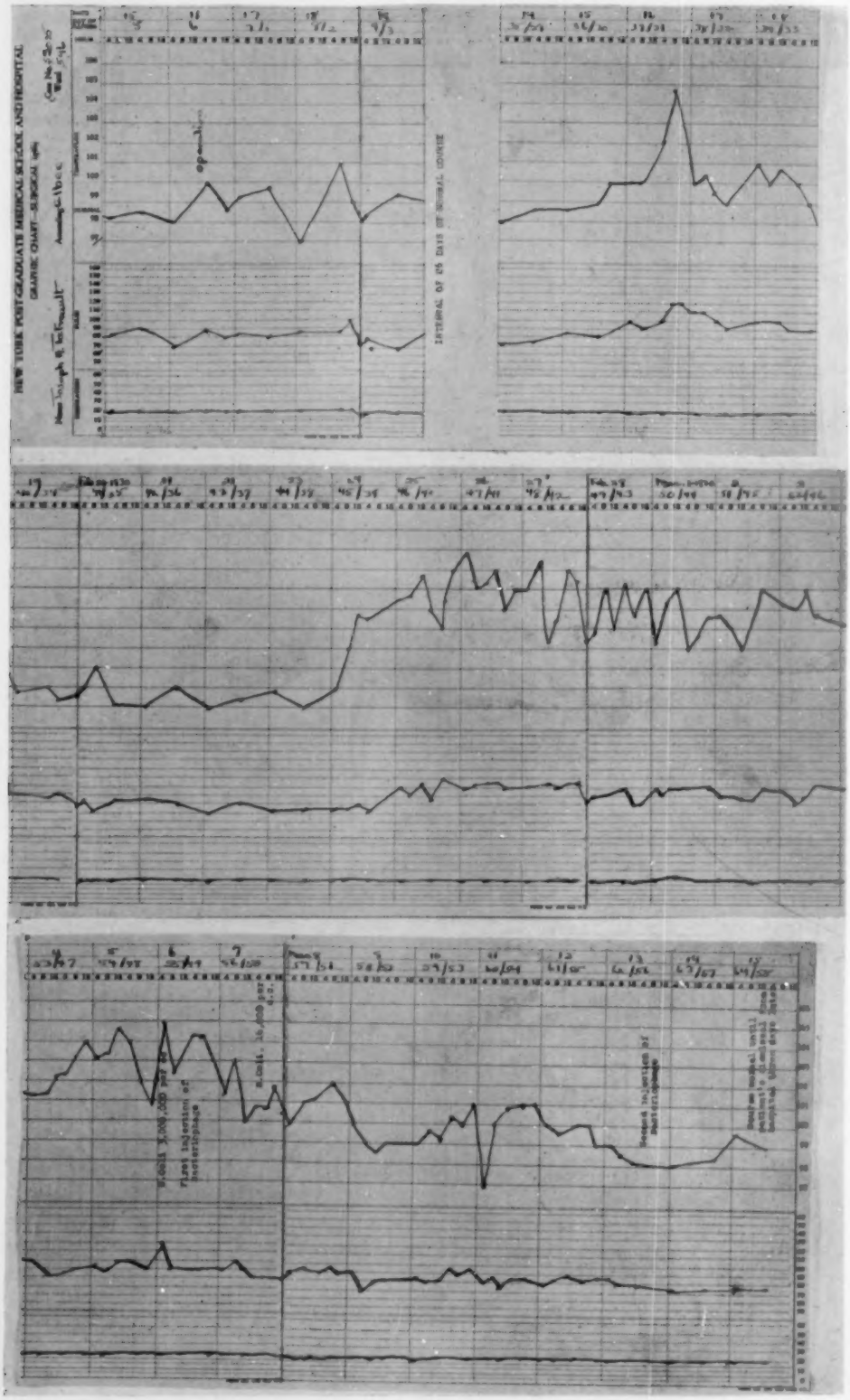
from the skin may be washed into the wound by the sweat. In spite of the general prevalence of diphtheroids and the frequency with which they occur as contaminants in the laboratory, our findings seem consistent in the fact that these organisms are seldom recovered from osteomyelitis wounds at operation unless the lesion be one of long duration. They were, however, present in large numbers toward the end of the period of observation and in some instances gained predominance in the flora. Their possible favorable prognostic significance is not discussed.

CASE VII (Graph 4).—In this case the patient, a man aged thirty-five years, had suffered a compound comminuted fracture of the left tibia and fibula as the result of being caught in the gears of a massive machine, September 19, 1929.

He was first seen by one of us (F. H. A.) four months later. The leg was found encased in a fenestrated plaster-of-Paris case, which had been applied six weeks before. There was a discharging wound with abundant unhealthy granulations six inches above the ankle on the anterior aspect. The leg was markedly distorted and palpation revealed malposition and non-union of the fragments. The X-ray (Fig. 1) confirmed the evidence of displacement and non-union and revealed an extensive mass of callus reaching from the superior toward the inferior fragment of the tibia. Several sequestra were also shown.

At operation the following day, January 16, 1930, the limb in the region of the osteomyelitis and pseudarthrosis was widely opened by an incision extending above and below the discharging wound. Several sequestra of considerable size were lifted out, and much thick pus and detritus removed with curette and dry gauze. Culture of the pus revealed Staphylococcus aureus (predominating), B. pyocyaneus and a few Staphylococcus albus. The bone surfaces were freed so as to be brought into alignment after the removal (with some difficulty) of the mass of callus. Then, with the Albee motor saw, the ends of the tibial bone fragments were shaped into the male and female parts of a mortise joint. The placement of the mortise, together with the straightening, brought about sufficient tension to hold the fragments in place, without the necessity for any internal fixative such as kangaroo tendon. As already stated, no germicide was used. When the fragments were restored, excellent alignment was attained (Fig. 2) but there was a great deal of dead space, especially on the posterior aspect where the mass of callus had been removed. This was packed with yellow vaseline supplemented with vaseline gauze placed more anteriorly in the wound. The value of this semi-fluid dressing has already been described; it was particularly advantageous in a case of this kind. The dressing was finished by the method already described, the plaster extending from mid-thigh to the bases of the toes.

For the next day or two there was moderate fever, but this soon abated. Convalescence was uneventful for about a month when the patient was seized with severe pain in the right flank. The temperature rose to a maximum of 104.4°. It quickly abated, but ten days later it rose again to the same level; pus was found in the urine, and Dr. Joseph J. McCarthy, called in consultation, diagnosed acute pyelitis of both kidneys. The urine was found negative for tubercle bacilli, but B. coli (acidi lactici) was present in large numbers (700,000 per cubic centimetres). The erythrocyte count was 2,750,000 per cubic millimetres and the leucocyte 12,800 per cubic millimetres. The urine was loaded with both types of blood-cells. The bacteriophage principle was again invoked. Under the direction of Doctor McCarthy, a specific bacteriophage was prepared and introduced by urethral catheter into each pelvis. At this time there were 3,000,000 colon bacilli per cubic centimetres of urine. The patient's reaction was very prompt. The temperature fell, his pain abated and he felt quite comfortable and regained his appetite. The day after this treatment there were only 16,000 bacilli per cubic centi-


NEW YORK POST-GRADUATE MEDICAL SCHOOL AND HOSPITAL
GRAPHIC CHART—SURGICAL
INTERVAL OF 25 DAYS OF NORMAL COURSE
First injection of bacteriophage
Second injection of bacteriophage

GRAPH 4.—(Case VII.) Temperature and pulse chart in a case complicated by pyelitis. The severe reaction is indicated particularly in the temperature curve, but the patient's response to the injection of bacteriophage was even more spectacular than that indicated by the temperature and pulse readings. The portion of the chart covering the uneventful period has been removed.

metres. The severity of the fever during the time required for the preparation of the bacteriophage is indicated in Graph 4, as is the fall of three degrees or more during the two following days. After the second similar treatment a week later, the temperature stayed practically normal. The condition on the day of the first treatment was serious as the temperature of 105° and pulse of 120 indicates.

Through this difficulty there was no indication that the leg was responsible and the dressing was not touched until the usual time had elapsed. Then it was found that the vaseline gauze had been entirely extruded, the wound was healed except for an area the size of one's thumb-nail, and bony union was almost complete.

Discussion.—Three cases have been reported in which it has been possible to recover races of anti-coli and anti-staphylococcus bacteriophage from wounds of osteomyelitis treated by the modified method of Orr. These lytic principles when isolated have shown specific action against bacterial strains present in the wound. Since it has been impossible to prove in vitro that the native lytic agent was active against more than one of the bacterial species constituting the wound flora, it would seem that the original pathogenicity of this organism, possibly altered by environmental factors, might have been a determining factor in the cause of the disease.

It is not our purpose at this time to enter into the controversy concerning the origin and proliferation of the bacteriophage but if we can assume for the moment that the principle multiples with destruction of the sensitive bacterial cells the sequence of events in Case I becomes clear. It will be remembered that while the wound was healing rapidly and favorably the B. coli manifested first its sensitivity and later resistance to the native bacteriophage which thus first failed to lyse the B. coli and finally disappeared before healing was complete. It seems fair to conclude that the B. coli while acquiring resistance to the bacteriophage lost virulence for the host and that the bacteriophage having no pabulum in the way of susceptible bacteria disappeared. Healing went on favorably because the service of the bacteriophage had been accomplished.

The explanation of Cases II and III is not so simple. In both these cases the bacteriophage isolated at the first examination disappeared, but the organism in the case, a staphylococcus, not only persisted but remained sensitive to the native bacteriophage previously isolated. If this is not attributable to a laboratory error the explanation can be afforded only by further investigation which may entail extensive serological studies as well as further studies in the morphology and antigenic properties of the organism isolated at various stages in the healing of the wound.

In bacterial studies one is ever mindful of the danger of comparing the result of reactions observed *in vitro* with those which may occur *in vivo*. It is not our conception that lytic action so vividly demonstrated in the test-tube proceeds at as rapid a rate in the wound where other environmental factors are to be considered, but that if this lytic principle is undisturbed in the wound a process, perhaps less rapid *in vivo*, may through its specificity eliminate or alter the virulence of invading organisms and thus facilitate healing processes and shorten the course of treatment in osteomyelitis. Since

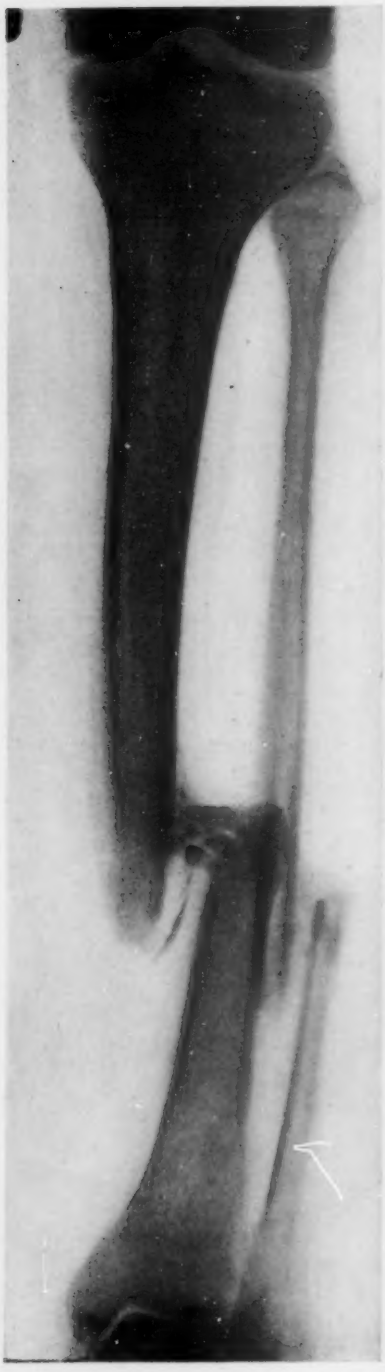


FIG. 1.—Ununited fracture of tibia and fibula in Case VII. Marked malposition and over-riding and non-union of the fragments are evident, as well as the extensive mass of aimless callus and the multiple sequestra.

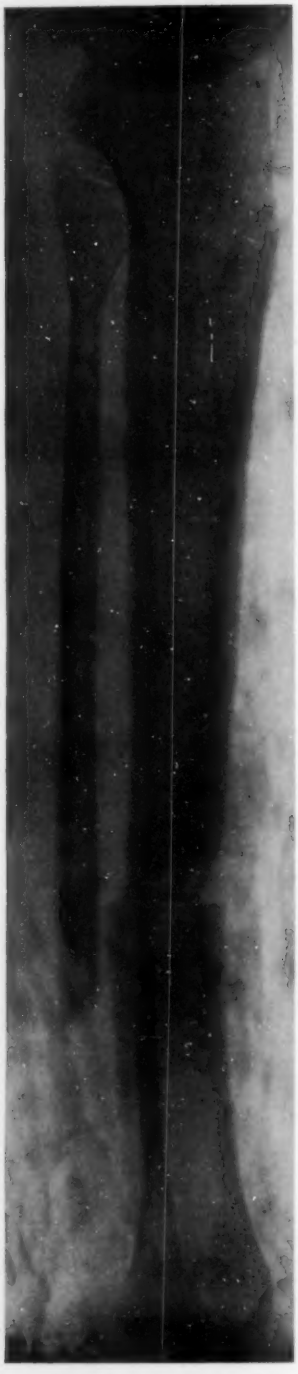


FIG. 2.—The same case showing the mortise, replacement and alignment of the fragments. Two months after the operation the callus was firm and the soft parts nearly healed.

this process appears to be one of the factors in healing, its significance can be ignored neither by the bacteriologist nor the surgeon.

It is to be hoped that the profession will manifest a reasonable and even conservative attitude toward the new facts which are being presented. If medical history repeats itself, the profession will be deluged with "bacteriophage," and the laity will be led to expect marvels from the "new serum." Even a cursory knowledge of the principles will suffice to convince one that the bacteriophage must be specific for the infecting organism. It is not enough to treat a B. coli infection with a B. coli bacteriophage; the specificity for the infecting strain must be determined in the laboratory. More than that, since it is probable (and from our investigations would seem certain) that the resistance of the infecting organism for the bacteriophage alters during surgical treatment, it cannot be expected that a bacteriophage specific for the infection today will unfailingly affect it a month or six months hence. The effect of the bacteriophage on its homologous strain (short of absolute lysis) is debated by the bacteriologists. When a wound in living tissue is substituted for the test-tube, it is difficult, if not impossible, to foretell the effect of the bacteriophage. In our cases, specificity lasted long enough for us to prepare a bacteriophage following one dressing and introduce it successfully at the next. We were careful, however, to test again for lysis following the treatment, so that we could be sure we had actually administered a potent substance. We do not expect specificity always to endure so long, but we shall at least know our position therapeutically, as far as it can be known with the present knowledge of the lytic principle. At the present time, in our opinion, there is no method of preparing "gun-shot" mixtures of bacteriophages which can be applied scientifically; and no way of applying these principles except with the coöperation of a bacteriological laboratory unless one is content to guess the way in a fog.

While d'Herelle's discovery is of great importance in bacteriology, and may eventually change the present conceptions of infection and immunity, the broad principle is as old as life itself, or almost as old. Since evolution was determined by the struggle for existence, warfare between the old and the new forms of life was probably its first manifestation. Struggle for existence, in the animal kingdom at least, is largely a struggle for mastery or escape. We see only the most evident part of it, but the warfare goes on in the soil, in the air, on the earth and in the waters under the earth. Sometimes victory goes to the swift and the strong, but the eventual master, returning flesh to its primitive elements, and often bringing death to the living, is the microscopic polyphage.

If the individual man is the eventual loser in the struggle, he is probably the gainer collectively. It is the nicely balanced warfare between man's enemies that keeps the earth safe for him. He can live only so long as there is a drawn battle; he survives pandemics, such as influenza, poliomyelitis and encephalitis lethargica, because he is rescued by some unknown foe of his enemy; just as the monsters that would have overwhelmed him before his

history began were destroyed to make way for him. True, some of the protection may have been afforded by the elements or climatic changes, but, in general, it is probable that man's menace eventually meets a menace of its own.

While much of this is speculation, there has been ample proof of the "friendship" of many forms of life for man. It has been applied to the protection of man's food supply. The control of the purple scale, so destructive of fruit trees, depends largely on this principle of letting somebody else fight our battle, and even encouraging him too. This insect pest is attacked by the red-headed scale fungus (which may be a Nordic among the vegetable races). The threads of the fungus ramify through the body of the insect, and eventually kill it as well as most of the eggs it contains. From the insect's point of view this is an awful disease; from ours it is a highly effective and beneficent one. As we eat our citrus fruit we may not suspect what a struggle for existence and what a history of carnage its perfection represents.

There are other forces in this silent battle. If the fungus does not arrive on the field, the lady-beetle attacks this pest. One would never suspect from its appearance that the lady-beetle was capable of such savagery as tearing up the females and eating them. Before the days of bargain sales one would have said there was nothing ladylike about it.

These are examples of the destruction of an insect by a fungus and by another insect. There are many examples of flies being attacked by insects. There is a small insect which lays its eggs within the body of the whitefly, another pest on citrus trees. The grub of the parasite feeds on the host's substance and finally kills it. So effective is this method of attack, and so abundant are the parasites, that the whitefly is destroyed before it can do any material harm. It manages to exist, however, so that the battle, by the latest bulletin, may be considered drawn.

It has been one of the dreams in therapeutics that a natural enemy might be discovered for each germ of disease. There must undoubtedly be one for some of them in nature somewhere, but so far only one has been given serious trial. Some success has attended the use of malaria in the treatment of late syphilis.

The fruit-growers are much more advanced in this respect than we are. They introduce predacious insects to destroy pests, and find the lady-beetle of so much value that they do everything to encourage it to populate their fruit groves. They do not spray trees with chemicals if they can make use of the much more effective living agent. The chemical is more harmful to the lady-beetle than it is to the pest.

These are only a few instances of how man puts his knowledge of biology to practical use. We protect birds and other creatures that destroy pests. In India they domesticate the mangoose for protection from snakes.

It would appear, therefore, that if the bacteriophage is a living creature, as d'Herelle and others assert, it furnishes only another example of the

struggle between natural enemies. The new fact is that it belongs to a form of life about which so little is known and which the bacteriologists are eager to investigate in the hope of discovering the causative agent of some of the unexplained infections. Although the question is still unsettled whether it is a living creature, more is known about it than about ultramicroscopic life in general. Its behavior has been closely investigated; its reactions in the test-tube and in the body have been observed; it has been separated in a comparatively pure state and chemically analyzed; it has even been measured.

As soon as it was definitely shown that there is a bacteriophage in the wounds treated by the Orr method, and that healing was delayed in a case in which the bacteriophage was not present and was accelerated by the introduction of this lytic principle, it was decided to omit germicides so as not to risk the destruction of the bacteriophage at the outset. It is too early yet to determine the results of this change in the technic, but it seems theoretically highly justifiable.

The many advantages of the closed method of treatment of chronic osteomyelitis have been already referred to.[1] Not the least of these is the economy, both in money and time. The patient spends a week, or perhaps a little more, in hospital following the operation. Subsequent changes of dressing are at such long intervals that the patient can remain at home; and the time required for the change is so short, and the reaction so slight that he need remain in hospital only over night.

This consideration is so important from the point of view of the cost of treatment and the necessity of economy of hospital space, that, even if the procedure were not vastly less exacting, it would be preferred by all who have experienced these advantages, even if the ultimate result were no better. As it is, the result, in contrast with those attending older methods, is almost miraculous in the average case.

The whole problem of the bacteriophage is too far from solution for one to hope to draw any sweeping conclusions from the investigation which we have reported. The demonstration of the bacteriophage in the material withdrawn from the lesions of osteomyelitis parallels its original demonstration in the bowel contents in cases of dysentery and in other lesions. We have not been able to concur exactly with d'Herelle that it is found only in the healing stages. It tended to disappear before healing was complete. Our findings may be interpreted, however, so as to parallel d'Herelle's conclusions. It may be that the presence of the bacteriophage indicates the potentiality for healing, if surgical treatment aids instead of interfering with healing.

Under the form of treatment described, the bacteriophage is neither destroyed by chemicals nor dissipated by methods of dressing. It would appear also that the infecting organism, of a variety of types, is reduced in virulence in the presence of its specific bacteriophage, since, although it does not disappear from the wound, it fails to retard noticeably the process of healing if the specific bacteriophage is present. The bacteriophage might,

then, be considered an additional factor in promoting healing of wounds in general and particularly in those of osteomyelitis.

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CLINICAL EXPERIENCE WITH GASTROPHOTOGRAPHY *

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In the diagnosis of diseases of the stomach and duodenum great reliance has come to be placed upon röntgenologic methods. However highly history, physical examination and analysis of the gastric chemistry may be regarded, the internist and the surgeon are loath to proceed with therapy without obtaining the information derivable from the barium meal—unless such examination is contraindicated by hæmorrhage, impending perforation or evidences of acute obstruction. Time has proven the value of the röntgen-ray examination but also has demonstrated some shortcomings. Small ulcers on the lesser curvature may be missed; larger ulcers and new growths near the cardia and on the posterior wall may be overlooked. It may be extremely difficult or impossible to decide whether a deformity of the stomach is due to an intrinsic or extrinsic lesion.

The gastroscope may give the desired knowledge in some of these problems but because of its risks and unpleasantness gastroscopy has found favor in few hands, particularly as it permits of only a limited range of vision.

The gastrophotor ‡ is an ingenious device invented by Mr. Back, whose researches were begun with Professor Porges and Doctor Heilpern † of the Wenckebach Clinic in Vienna, and continued here in New York. It aims to give the additional information required, providing a greater range than gastroscopy and lacking the unpleasant features. It consists essentially of a semiflexible tube carrying at its distal end two cameras, an upper and a lower, between which is the source of light. This is operated by the transformer and yields a bluish-white flash of 12,000 candle power for 1/120 of a second. Each camera contains four small films circularly disposed, each covering 90 degrees of the circumference by means of two pinholes, upper and lower, and yielding stereoscopic photographs. Thus at one exposure eight double, stereoscopic views are obtained. The fasting stomach is first evacuated by introducing a stomach tube and placing the patient on his left side in the Trendelenberg position, applying suction or positive pressure through the tube (Schindler's method). With the patient sitting up the apparatus is introduced, the stomach inflated with air, the shutter opened, the transformer button pressed, the shutter closed and the apparatus withdrawn. The films are developed and the enlargements (10 times) made for reading. In

* Presented before the Surgical Section, New York Academy of Medicine, March 7, 1930.

‡ The gastrophotor is made by the Photor Corporation, 386 Fourth Avenue, New York, N. Y.

† Klinische Wochenschrift, January 4, 1930, p. 15.

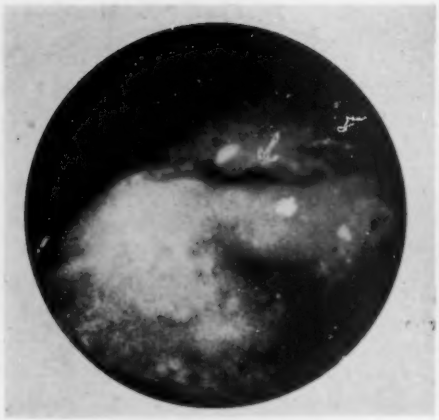

FIG. 1A.—Gastrophotograph. Ulcer of lesser curvature, with œdematous margin, malignant.

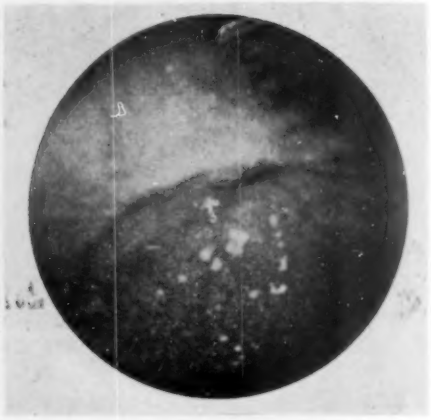

FIG. 1B.—Gastrophotograph. Showing furrow on greater curvature produced by operative procedure used in covering perforation.

FIG. 1C.—X-ray taken five weeks after operation for acute perforation, showing large penetrating lesion.

deciding upon the most favorable position for the cameras the knowledge gained as to the shape of the stomach from the X-ray films is utilized. The fluoroscope may be employed for more accurate localization of the apparatus. It is frequently advisable to make an upper (fundal) exposure and a lower (antral) exposure, particularly when the site of the suspected lesion is not known.

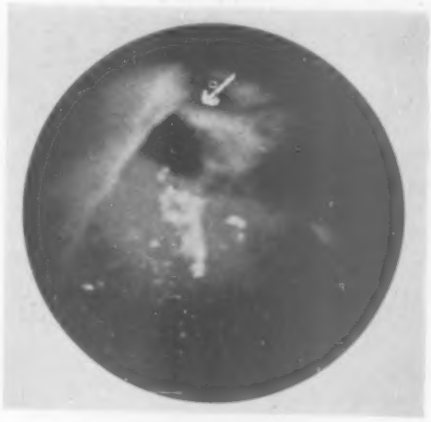

FIG. 2A.—Gastrophotograph. Ulcer on lesser curvature. Antral fold.

The apparatus and films are marked so as to permit of orientation. It is also possible to determine the appropriate size of the lesions, by measuring the distance between identical points on stereoscopic photographs. Considerable experience is required to read and interpret the pictures. Skill in doing so may best be acquired by checking against operative or autopsy specimens of cases in which the examination has been made. Gastrophotography has been carried out with the aid of Mr. Back in twenty-one cases.

In the following report I present cases in which the result of the examina-

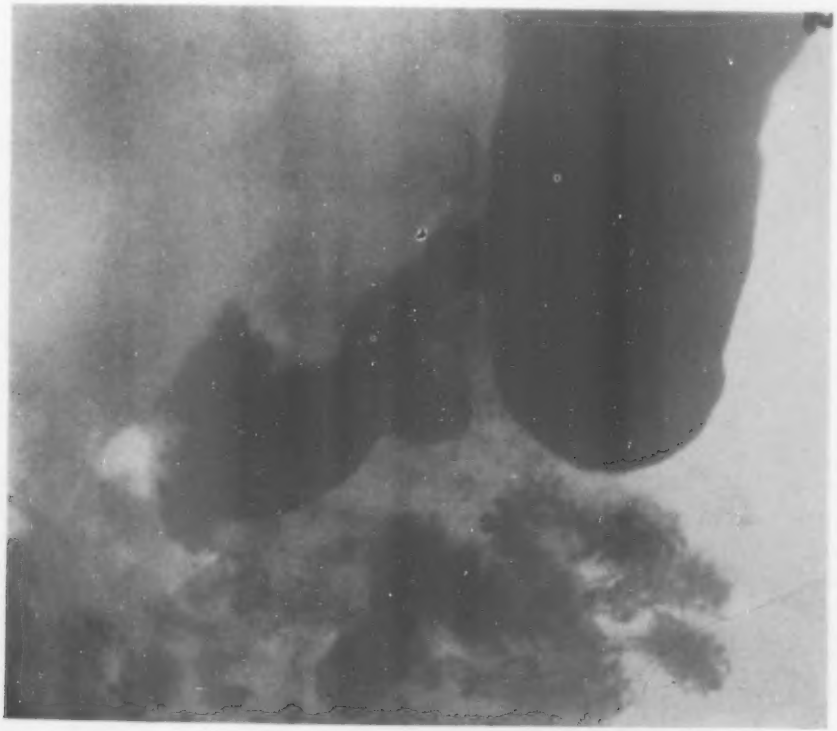

FIG. 2B.—X-ray showing hour-glass deformity and niche on the lesser curvature.

tion has been subjected to the test of surgery or post-mortem investigation, submitting illustrations of the X-ray findings, the gastrophotographs and the specimens.

Case I.—H. K., Hosp. No. 307455. A man of sixty-one years with an eight-year history of remittent periods of typical ulcer pain was admitted October 8, 1929, with epigastric tenderness and rigidity. The symptoms and signs of perforation appeared on October 10, free air under the diaphragm being demonstrated by X-ray. At operation I found on the anterior wall of the stomach just below the œsophageal entrance and involving the lesser curvature, an indurated lesion five centimetres in diameter, at the centre of which was a small perforation. The site of the lesion made resection inadvisable. Because of the œdema and infiltration the perforation had to be covered by bringing the uninvolved anterior wall near the greater curvature up over the lesion, greater omentum was used as a second suturing it to the lesser omentum. The barrier. The patient recovered but was subsequently readmitted for recurring ulcer symptoms, which yielded at first to medical treatment directed by Doctor Grohn.

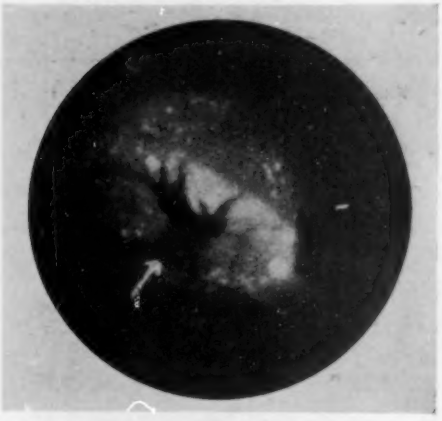

Fig. 3A.—Gastrophotograph. Carcinomatous ulceration.

When symptom free a gastrophotograph was made December 4, 1929. This showed (Fig. 1A) an ulcer on the lesser curvature about one and a half inches in length surrounded by an œdematous raised area. There was also seen (Fig. 1B) a longitudinal furrow on the greater curvature caused by the plication which had been used to cover the perforation. An X-ray study was made five weeks later (Fig. 1C).

Subsequently recurring symptoms and loss of weight, after the initial remarkable gain, enforced surgical intervention (March 5, 1930). A large penetrating lesion of the lesser curvature above the re-entrant angle and juxtacardial in location was found. The resected specimen proved to be carcinomatous.

Case II.—J. D., Hosp. No. 224674. Admitted in November, 1922. This man of fifty-six had a three months' history of anorexia and epigastric pain. Ewald test meal showed free acid, 30, total 55. Barium meal revealed a large penetration on the lesser curvature. At exploration Doctor Lewisohn found a large lesion which he considered an inoperable ulcerated carcinoma at the site indicated by the X-ray. An omental nodule removed for section showed no evidence of cancer. The clinical diagnosis of malignancy was proven erroneous by subsequent events.*

In June, 1924, the patient had lost no weight, was practically free of symptoms and X-ray examination showed only a small niche high up on the lesser curvature. In 1925 the stomach presented an hour-glass deformity and a minute niche just below the cardia. In 1928 the niche had disappeared. The man has remained in good general condition and is practically free of symptoms. He recently submitted to gastrophotography. This showed a large ulcer on the lesser curvature (Fig. 2A), partly obscured by a curtain-like fold which is probably the antral fold or sphincter drawn upward and accounting for the hour-glass appearance observed in the X-ray films. The photograph indicates that despite absence of symptoms the lesion has again become active.

An X-ray examination made on March 4, 1930, showed an organic hour-glass

* Doctor Lewisohn has reported this case in the Annals of Surgery, 1926, vol. lxxxiii, p. 466.

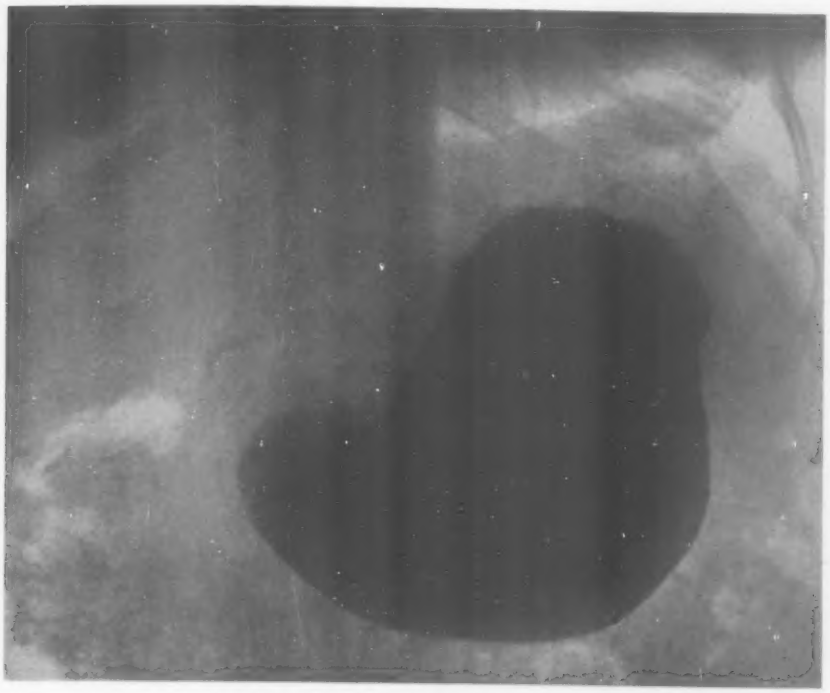

FIG. 3B.—X-ray. Pyloric obstruction, deformity of bulb.

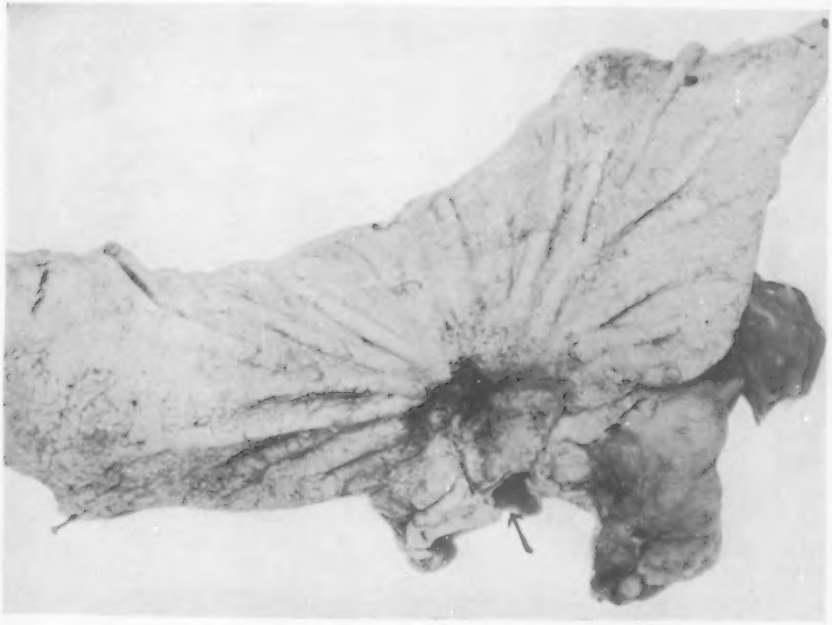

FIG. 3C.—Resected stomach. Prepyloric carcinoma ulceration.

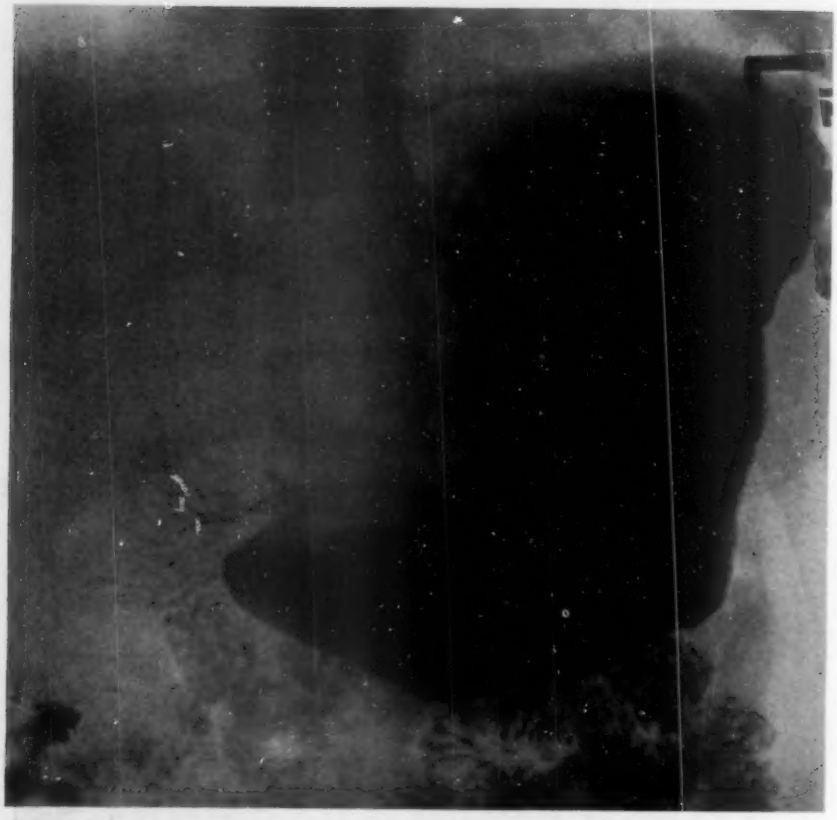

FIG. 4A.—X-ray. Deformed stomach. No niche demonstrable.

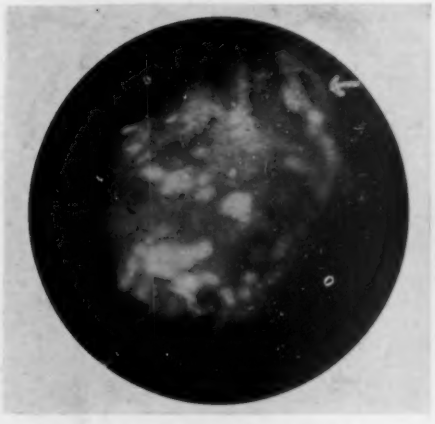

FIG. 4B.—Gastrophotograph. Ulcer of lesser curvature.

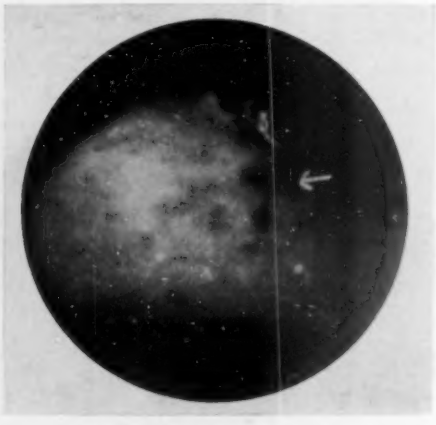

FIG. 4C.—Gastrophotograph. Gastritis of posterior wall.

deformity of the stomach with a projection from the lesser curvature opposite the incisure (Fig. 2B).

Case III.—S. K., Hosp. No. 308020. A woman of fifty-five years, with eight months' history of epigastric pain, vomiting, hæmatemesis and melæna, loss of weight and strength. Despite treatment she became worse and developed gastric retention. Gastrophotography December 4, 1929 (Fig. 3A), showed a deep, cratered ulcer with irregular, heaped-up margin about one and a half inches in diameter. It was allocated to the greater curvature and considered to be carcinomatous. X-ray examination December 10, 1929, showed a large dilated stomach, poor tonus, deformed bulb and large residue (Fig. 3B); the diagnosis was duodenal ulcer. Operation December 18, 1929, revealed a large carcinomatous crater involving the lesser curvature of antrum

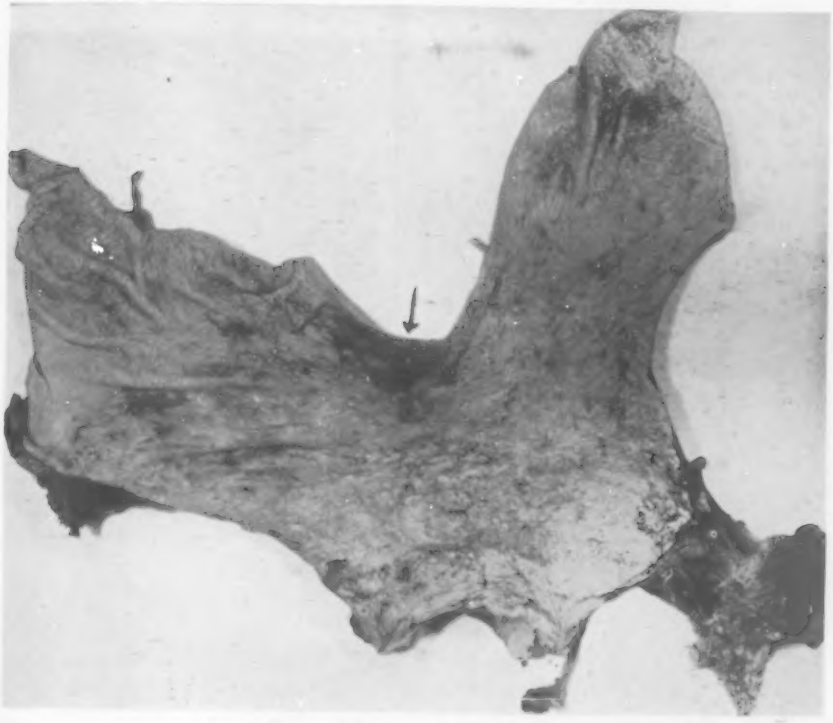

Fig. 4D.—Resected stomach. Ulcer at re-entrant angle.

and pylorus. The specimen resected by Doctor Berg (Fig. 3C) shows that the lesion corresponds to the gastrophotograph. It seems that the error in localization was caused by incorrect marking of the films.

Case IV.—B. C., Hosp. No. 309621. A man of forty-two years following an injury was operated upon in 1916 for a perforating lesion of the stomach (ulcer?). In 1920 he began to have pain coming on two hours after meals and relieved by food. In 1923 the gall-bladder was removed without relief of symptoms. In 1924 another surgeon explored for suspected duodenal ulcer, but discovered only extensive perigastric adhesions. There was no relief, and he came to this service December 14, 1929. Fractional test meal yielded free acid 20, total acid 24. Barium meal showed a deformed, somewhat hour-glass-shaped stomach; no niche demonstrable (Fig. 4A). Gastrophotography showed an ulcer on the lesser curvature (Fig. 4B) and evidences of gastritis on the posterior wall (Fig. 4C). Operation revealed a stomach imbedded in adhesions with an ulcer at the re-entrant angle. The specimen resected by Doctor Berg is shown in Fig. 4D.

FIG. 5A.—X-ray. Prepyloric annular defect.

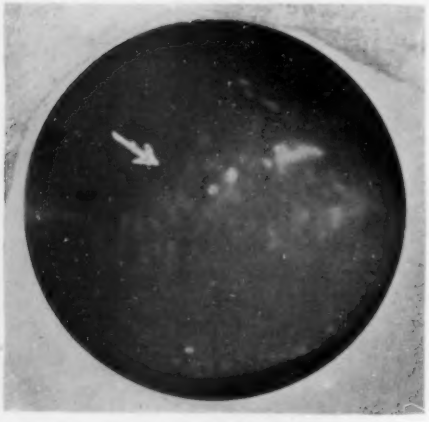

FIG. 5B.—Gastrophotograph. Small ulcer on lesser curvature.

CASE V.—S. P., Hosp. No. 309629. A man of thirty-six with two years' history of left epigastric pain radiating into the dorsal region, especially severe at night. Food and alkalies afforded relief until four months ago since when the pain had become persistent and more intense. Fractional test meal showed free acid of 60, total 96. Barium meal revealed a persistent prepyloric annular defect indicative of neoplasm (Fig. 5A). Gastrophotography showed a small ulcer on the lesser curvature (Fig. 5B). At operation Doctor Berg found extensive perigastric adhesions and a mass in the pyloric region. Resection was carried out above the re-entrant angle. On opening the specimen the pyloric mass proved to be a greatly hypertrophied pyloric musculature, but a small ulcer corresponding to that seen in the gastrophotograph was present on the lesser curvature near the proximal line of resection (Fig. 5C).

FIG. 5C.—Resected stomach. Hypertrophic pylorus. Small ulcer at re-entrant angle.

CASE VI.—C. R., Hosp. No. 309728. A man of fifty-nine suffered for one year with severe pain radiating from epigastrium to left lower chest and back, coming on two hours after meals, relieved at first by food and alkalies. Then pain became intractable, he lost weight and strength. Melæna occurred. Carcinoma was suspected. Gastric analysis yielded no marked deviation from the normal. Gastro-intestinal X-ray had to be made with the patient recumbent and although there seemed to be a small niche at the re-entrant angle the radiologist would make no definite diagnosis (Fig. 6A). The gastrophotograph (Fig. 6B) was suggestive of an ulcer at the lesser curvature but this also was not definite. At exploration I found a small indurated area at the re-entrant angle and resection was carried out with complete relief. The specimen presented (Fig. 6C) a small ulcer about four millimetres in diameter.

CASE VII.—M. G., Hosp. No. 301857. A man of forty-eight with thirteen years' history of epigastric pain at first relieved by food but becoming more persistent and intense. In April, 1929, he was explored by me although X-ray investigations of kidneys,

FIG. 6A.—X-ray. Recumbent position. Questionable niche.

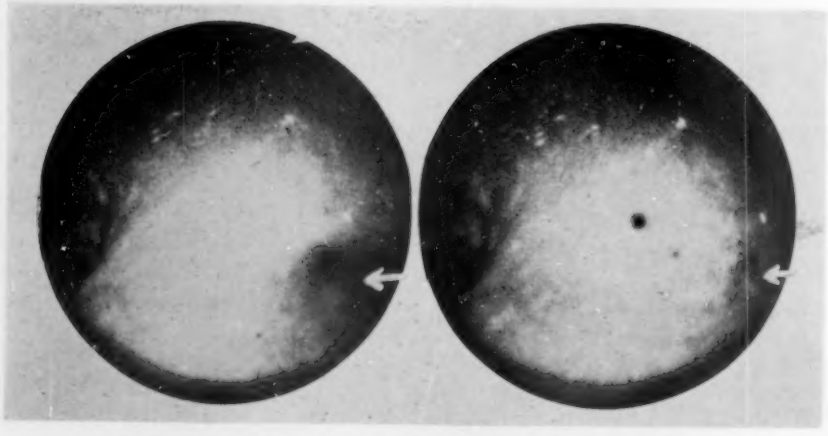

FIG. 6B.—Gastrophotograph. Questionable lesion of lesser curvature.

gall-bladder and gastro-intestinal tract were negative. At this time I had not begun using the gastrophotor. Exploration proved negative. Broncho-pneumonia supervened and as a result of coughing the wound ruptured.

In November, 1929, he returned for renewed and aggravated epigastric pain with radiation into the back and vomiting. A large incisional hernia was repaired without exploration of the viscera. Five weeks later he was readmitted for persistent severe pain and melæna. He had lost weight. There was tenderness in the left upper quadrant. Fractional meal showed free acid 75, total 120. Stomach contents and stools contained occult blood. Barium meal revealed a defect involving the antral and prepyloric areas with formation of a large irregular penetrating lesion extending almost to the cardia. The radiologist reported neoplasm of the stomach (Figs. 7A and 7B). Gastrophotography

FIG. 6C.—Resected stomach. Small ulcer at re-entrant angle.

showed a large crater on the lesser curvature and posterior wall with an irregular moth-eaten margin (Fig. 7C). At operation a huge, penetrating, carcinomatous ulceration was found. It is apparent that a small lesion was missed at the first exploration and that it had rapidly progressed. It is in such cases with negative X-ray findings that this new method may yield important and helpful information.

CASE VIII.—L. P., Hosp. No. 310740. A man of forty-eight in excellent health until three months ago, noted epigastric pain radiating to the left hypochondrium, persistent and not related to food intake. Fractional analysis showed free acid 50, total 64, with blood in all specimens. Barium meal revealed a large penetrating lesion at the re-entrant angle, one and a half inches in diameter (Fig. 8A). At six hours some barium was still present in the pocket. The gastrophotograph showed an elliptical punched-out ulcer on the lesser curvature or posterior wall. It appears in the illustration one-third to one-fourth the natural size (Fig. 8B). At operation a large penetration was found extending from a crateriform lesion of the lesser curvature and posterior wall. Resection was carried out and the specimen proved to be an adenocarcinoma (Fig. 8C and Fig. 8D).

CASE IX.—M. G., Hosp. No. 306972. This man of sixty-two had a posterior gastrojejunostomy performed by Doctor Lewisohn, at the Beth Israel Hospital, in 1913, for an ulcer at the pylorus. In 1920 at Mount Sinai Hospital, he had clinical and X-ray evidence of gastrojejunal ulcer. Relieved by medical management, he was discharged. In the summer of 1929 he came to the out-patient department of the Sydenham Hospital,* complaining of postprandial pain, pyrosis, vomiting and rapid loss of weight. Fractional meal showed free acid 60, total 135. Barium meal revealed a large stomach, exaggerated peristalsis, considerable retention and pyloric obstruction attributed to neoplasm or

FIG. 7A.—X-ray. Antero posterior. Irregular antrum.

adhesions. A gastrophotograph made soon thereafter showed a crateriform ulcer on the lesser curvature with mucosal folds radiating from it, suggesting that the lesion was in the prepyloric area (Fig. 9A). On September 24, 1929, he again entered Mount Sinai Hospital, where X-ray examination showed pyloric obstruction, gastric retention, and a poorly-functioning stoma with a patch of barium indicating a jejunal ulcer (Fig. 9B). While under observation he developed signs of acute perforation. At operation Doctor Lewisohn found a pin-point opening in the jejunum near the old stoma, and a large subhepatic abscess. The perforation was closed and jejunostomy performed. He ceased the next day. The post-mortem examination showed a healed pyloric ulcer with stenosis, a large chronic peptic ulcer on the lesser curvature, prepyloric in location, and a repaired perforation of a jejunal ulcer which had caused obstruction at the stoma.

* I am indebted to the Sydenham Hospital for the use of its record in this case.

FIG. 7B.—X-ray. Oblique. Large irregular penetration.

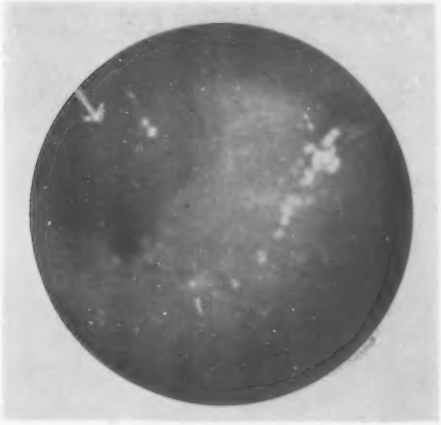

FIG. 7C.—Gastrophotograph. Large crater with irregular moth-eaten edge.

FIG. 8A.—X-ray. Large penetration.

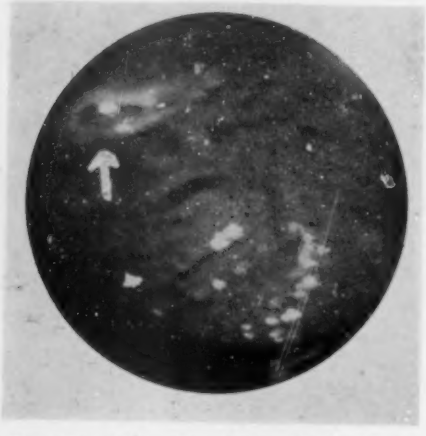

FIG. 8B.—Gastrophotograph. Mouth of the penetration, one-fourth the natural size.

FIG. 8C.—Resected stomach viewed from the exterior.

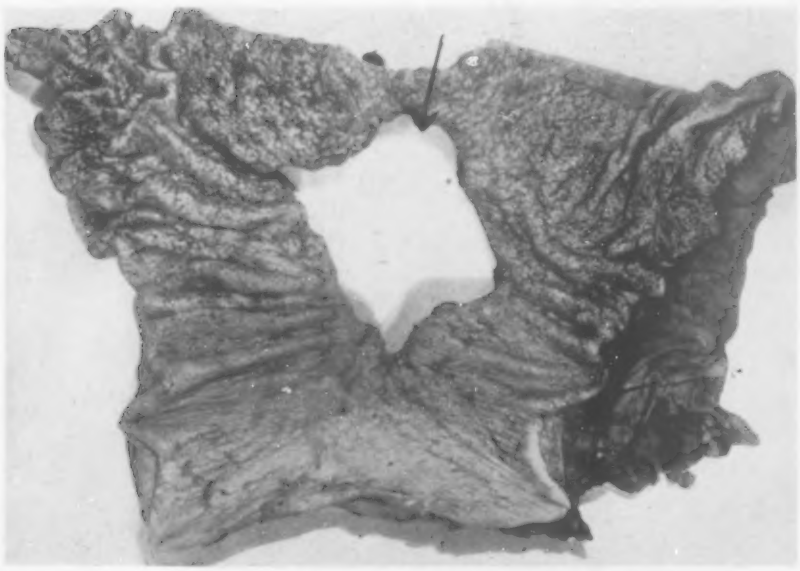

FIG. 8D.—Resected stomach viewed from the interior, showing crater.

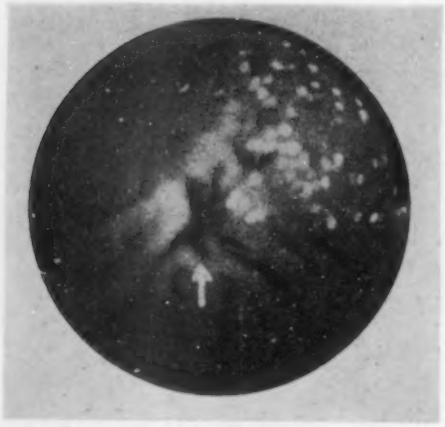

FIG. 9A.—Gastrophotograph. Ulcer of lesser curvature.

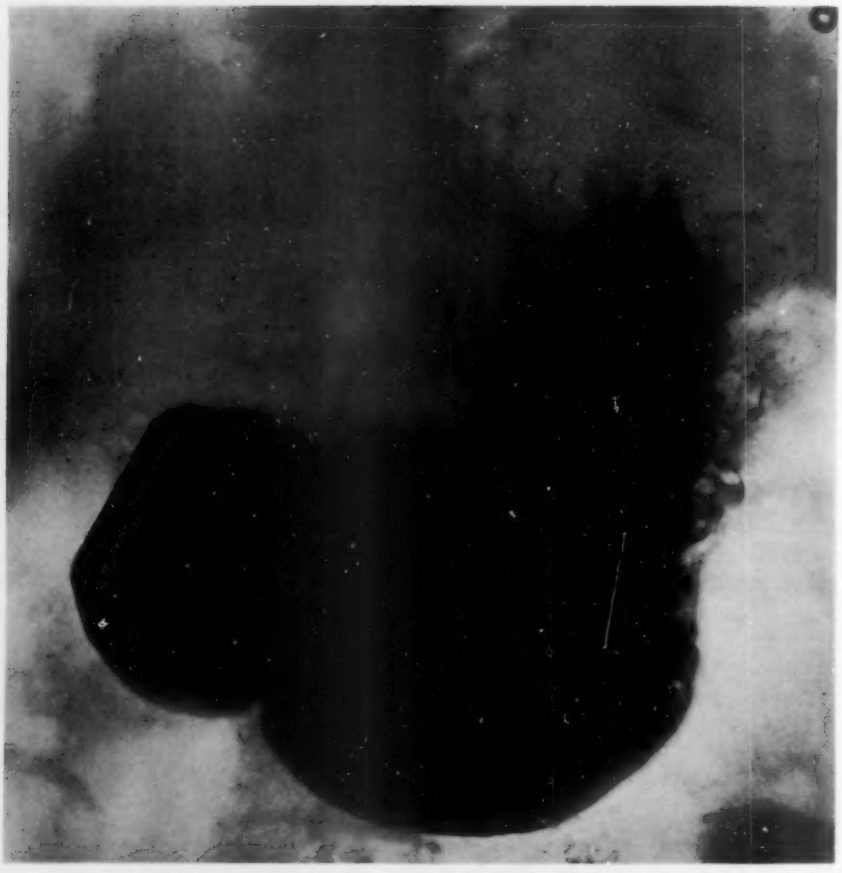

FIG. 9B.—X-ray. Pyloric obstruction, poorly functioning stoma.

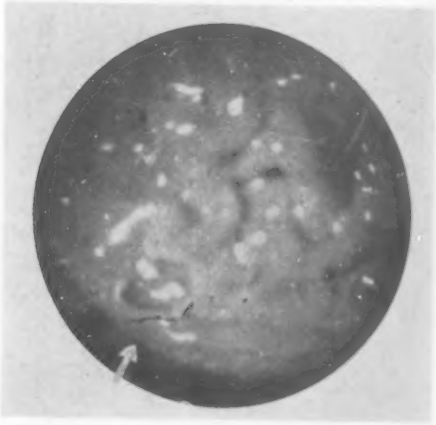

FIG. 10A.—Gastrophotograph. Ulcer.

FIG. 10B.—Autopsy specimen showing corresponding lesion of antrum.

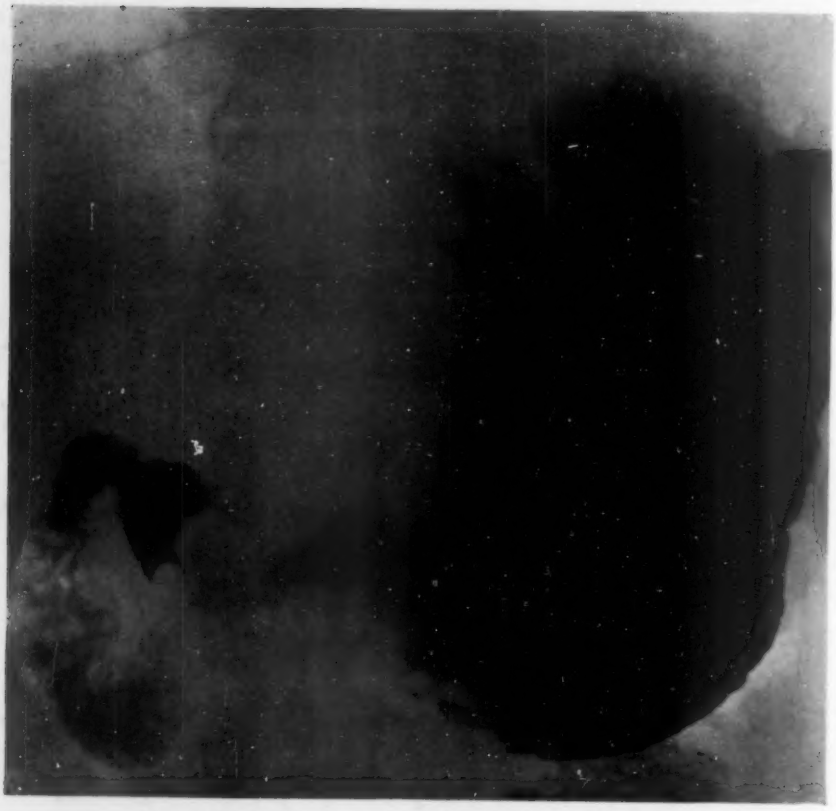

FIG. 11A.—X-ray. Large irregular filling defect of antrum.

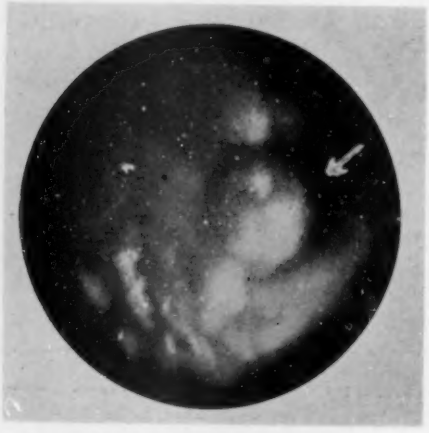

FIG. 11B.—Gastrophotograph. Fungating carcimona of greater curvature.

CASE X.*—B. S., aged sixty-nine years, complained of pain in left upper quadrant two hours after meals, with periods of remission, for eight years. Three months ago the symptoms returned with greater severity and were not relieved by diet or medication. Ewald meal showed free acid 20, total 60. X-ray examination showed nothing definite in the stomach; the duodenum was normal. The prepyloric region was tender. Gastrophotography revealed a definite ulcer (Fig. 10A). The patient was explored but no ulcer found, although the surgeon, a man of skill and wide experience, did a gastrotomy for inspection and palpation. About five days later the patient died of cardiac failure. A post-mortem examination showed a small callous ulcer on the lesser curvature about 4 centimetres proximal to the pylorus. Its crater was about 1.0 times 0.5 centimetres in size, and the serosal surface of the stomach showed no gross changes at the site of the lesion (Fig. 10B).

CASE XI.—S. L., Hosp. No. 309378. A man with six months' severe, constant, epigastric pain followed by loss of weight and strength, anæmia and œdema. A large mass presented in the epigastrium. There was marked gastric retention and achlorhydria. Barium meal showed a large irregular filling defect of the lower two-thirds of the stomach (Fig. 11A). Gastrophotographs showed a large fungating carcinoma involving the anterior wall and greater curvature (Fig. 11B). No operation was performed as the case was too far advanced.

The results of X-ray and gastrophotography employed in twenty-one cases may be summarized as follows:

1. X-ray diagnosis and gastrophotography agreed in nine cases. Of these the diagnosis was correct as checked by operation in six cases. Not submitted to operation: three cases of carcinoma, considered clinically inoperable.

2. X-ray diagnosis and gastrophotography disagreed in six cases. Of these the X-ray diagnosis was proved correct by operation in one case, duodenal ulcer. Gastrophotography was proved correct by operation in three cases. Gastrophotography was proved correct by autopsy in two cases.

3. Neither method yielded a positive diagnosis in one case, a very small ulcer at the re-entrant angle.

4. Not submitted to exploration as yet, five cases.

CONCLUSIONS

Gastrophotography is a valuable adjunct in the diagnosis of lesions of the stomach. Of twenty-one cases examined, thirteen were checked by operation or autopsy and of these gastrophotography gave more reliable information than the barium meal in five cases. The natural limitations of the method preclude obtaining direct evidence in lesions of the duodenum and jejunum. Here the röntgen-ray method must be relied upon at present.

As to the benign or malignant nature of a large ulcer, absolute conclusions cannot be drawn from either the X-ray or the gastrophotograph. In any patient suspected of a gastric lesion, gastrophotography should be employed despite positive, doubtful or negative X-ray findings. A more extended application of the method is highly desirable, for the results thus far obtained surely indicate that it has real merit.

*I am indebted to Dr. R. Finkelstein, gastroenterologist of the Brownsville and East New York Hospital, for the privilege of reporting this case.

SIMPLIFIED TREATMENT OF THORACIC EMPYEMA*

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of Galveston, Texas

from the medical department of the university of texas

The basis for this paper has been a study of a series of eighty-one consecutive empyemas treated in the Surgical Service of the John Sealy Hospital, Galveston, Texas. It does not include a number of untreated terminal cases which occurred in the medical service, or cases found at autopsy complicating some other serious disease. Tubercular empyemas also have been excluded.

Practically all of these were preceded by pneumonia or influenza. It is safe to say that pneumonia is less common in the far South than in the more northern states, and there is also a decidedly lower mortality, with correspondingly fewer cases complicated by empyema. The mortality in this series of cases, as compared to reported statistics available from institutions elsewhere, is generally lower. This is likely due to the milder pneumonia, or may be to the method of treatment.

The accompanying chart shows the mortality in this series:

Eighty-one Cases of Empyema as to Age, Sex and Result

Age	Result			Mortality, per cent
	Recovered	Died	Total	
Under 5 years	12	1	13	7.6
5 to 20	27	0	27	0
20 to 40	23	1	24	4.2
Over 40	14	3	17	17.6
Total	76	5	81	6.3

Males, 58; females, 23.

The cause of death in our series was as follows:

Case I.—A child, age fourteen months, female, colored. The child had never been properly nourished. She entered the hospital with a history of an injury one week before and was found to have the right chest full of pus, an abscess in the cellular tissues of the orbit, and an abscess about the median end of the clavicle. The abscesses were opened and the empyema drained. The child was very septic with pyemic abscesses and died of exhaustion sixteen days after admission. Autopsy findings showed the following: Fibro-purulent pleurisy, bilateral; purulent arthritis of the left sternoclavicular joint, also osteomyelitis of the fifth, sixth and seventh ribs, bilateral septic pneumonia, acute entero-colitis, acute splenic tumor and cellulitis of the right eye.

Case II.—A man thirty-four years of age. The patient's trouble began with a

* Read before the Southern Surgical Association, December, 1929.

peri-urethral abscess complicating a stricture of the urethra, which was drained; and his convalescence was very slow. He returned to the hospital several weeks later with a well-developed empyema (streptococcic organisms were found) and there was an abscess underneath the skin where his chest had been previously aspirated. A rib was resected and drainage instituted. The abscess cavity continued to drain and the patient's health remained poor for about a year. A chronic sinus continued present in the perineum. At this time the patient attempted suicide by cutting his throat just below the hyoid bone and into the pharynx, and developed septic pneumonia, dying shortly afterward. Autopsy findings were a self-inflicted wound of the neck; large sinus in the left side communicating with pyogenic membrane over the lung, acute purulent bronchitis, right side, enlarged spleen, chronic cirrhosis of liver and acute glomerulo nephritis.

Case III.—Male sixty-five years of age. The patient entered the hospital with anasarca from cardiovascular disease and on examination he was found to have œdema of feet, a heart murmur, dilated heart, fast pulse and the right side dull. Aspiration

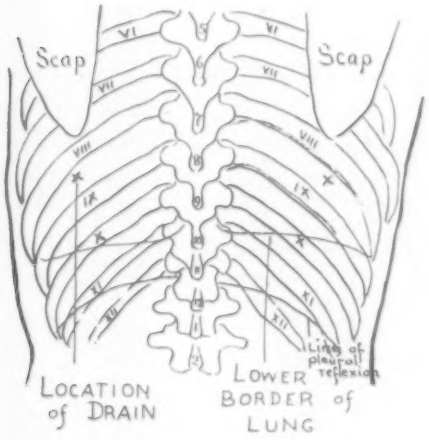

Fig. 1.—(X) indicates location of drain.

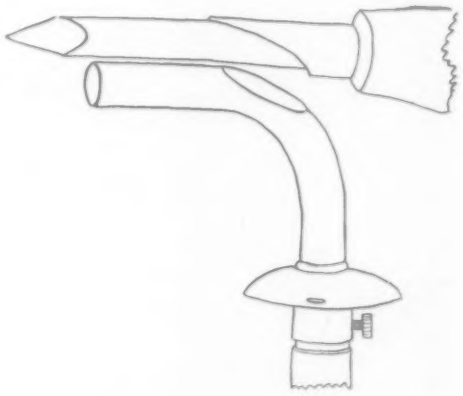

Fig. 2.—Trocar and cannula. Cannula left in place sutured to skin.

showed pus. A drainage tube was inserted and the second night afterward the patient in some way got the drainage tube out of his chest. A rubber tube was inserted, and there drained a large quantity of pus until he died three weeks later. No autopsy secured.

Case IV.—Female, age forty-five years. The patient entered the medical service with lobar pneumonia on January 28th. Following a stormy pneumonia she developed empyema, and on April 19 she was transferred to surgery with a diagnosis of empyema of the right side. She had been spitting considerable pus for several days. She was drained the next day. The patient suffered much pain, her pulse became weak and she died April 29 (nine days after drainage). Autopsy findings showed atheromatous aorta; empyema, right; infarct of spleen; hæmorrhagic pancreatitis; pneumonia of the left lower lobe; acute nephritis.

Case V.—A colored woman, fifty-three years of age. The patient came into the hospital with an empyema of the right side. She was cold and clammy; pulse 120-140, and almost uncountable. She was delirious, tossing about, tearing off bandages, and never controllable. She had to be forced to take her food by nasal feedings. Delirium continued and a toxic diarrhœa developed. She never improved, living fifteen days after drainage. An autopsy was not secured.

CONSIDERATIONS BEARING UPON

Treatment.—There are many things to be considered in treating empyema. Bacteria which produce the suppuration are quite a determining factor in the mortality as well as in the treatment. Those cases of streptococcic origin, which often occur early in the pneumonia, are more serious than the pneumococcic types which usually follow the pneumonia and occur after quite a degree of resolution has occurred in the lung. Also those cases which are drained with the lung in a crippled condition will have a higher death rate than those drained after a period of delay, until the lung is not so greatly embarrassed by consolidation, and is able to maintain a larger amount of tidal air.

It is unnecessary to state that drainage is the treatment for a frank pleural suppuration, but the question of when drainage should be restored to is debatable. The very high death rate from empyema in the various camps during the late war was quite noticeable. The empyema commission,

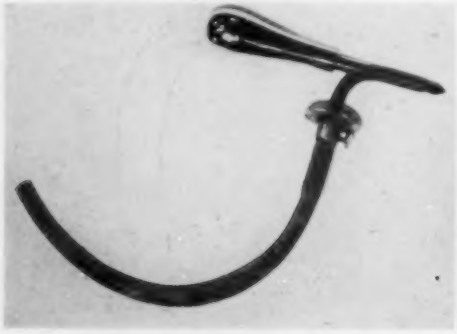

FIG. 3.—Trocar and cannula with rubber tube attached.

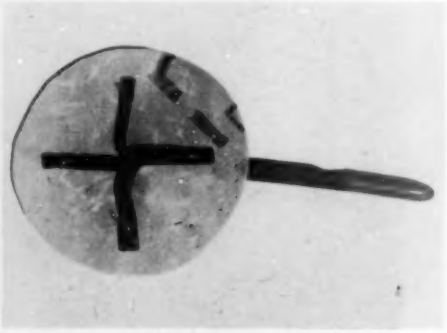

FIG. 4.—Home-made drainage tube which is used after cannula is removed.

at some of the military camps, observed that early drainage was followed by a higher mortality than delayed drainage. Also that chronic empyema and blood-stream infection were more likely to follow early drainage. A delay in drainage is unquestionably preferable because of the following reasons. First, it allows useful adhesions to form between the lung and the parietal pleura, and, therefore, less retraction of the lung will take place after drainage. Second, as Graham has pointed out, the mediastinum is very flexible normally and delay allows the mediastinum to become more fixed by inflammation and adhesions, and the function of the normal side of the chest is not disturbed to so great an extent after drainage. Third, further resolution in the diseased lung will take place, insuring better lung function at the time of drainage. Fourth, repeated aspiration and drainage delayed from seven to ten days allow the development of an immunity to the infection, and upon this self-immunizing process probably depends the recovery of empyema, as well as all other diseases of an infectious nature.

Open vs. *Closed Drainage*.—While rib resection with open drainage has been and still is the favorite method, on the other hand there is a growing tendency to use some form of closed drainage.

The first suction drainage apparatus for empyema was used by Brilan, of Vienna, in 1890. Perthes also in 1901 used a closed method with intermittent suction. Of the many advocates of closed drainage, the following reports will indicate the trend to this method. McKenna [1] reports nineteen adults treated without a death by trocar and cannula and catheter by repeated aspiration with a syringe. Mozingo [2] reports sixty-nine cases of acute empyema with three deaths treated by trocar and tube, and suction with syringe with the use of Dakin's solution, glycerine and carbolic acid. Alexander [3] uses a closed method of drainage with the tube entering the chest obliquely through

FIG. 5.—Drainage completed. Tube filled with water and end placed under water causing syphonage drain.

the chest wall. Hart [4] uses a closed method with continuous tidal irrigation with a special apparatus. Soresi [5] uses an apparatus with a valve producing a closed drainage with wonderful success. Freed [6] reports from the U. S. Veterans Hospital a study of one hundred cases. He says, "Men operated upon by the open method have at the expiration of so long a period more disability, and in some instances, they are totally incapacitated, and further, the open method with its numerous modifications, whether it be costocetomy or thoracotomy is gradually becoming more in disuse for some form of occlusion treatment." Davis [7] uses a pneumatic bag to keep the cavity air-tight with closed drainage. Parton [8] describes a rather simple apparatus for continual suction over a long period of time. Hart [9] has devised an ingenious apparatus which produces tidal irrigation and drainage dependent upon normal respiratory moments. McGlannan,[10] Whitte-

more,[11] Ransohoff,[12] and others have written excellent articles and reported results highly favorable to the closed methods of treatment.

Method of Drainage.—For a number of years we have practised a modified closed method of drainage (Figs. 1-6) and the eighty-one cases reported, with the exception of one rib resection, have been treated in this way. In four small infants an 18 F. rubber catheter was placed into the chest between the ribs with an ordinary trocar and cannula, while in all other cases the trocar and cannula drain here illustrated was used. This treatment was developed in the service some eight years ago during the administration of Dr. J. E. Thompson. There are two sizes of the tube, one for children and one for adults. The trocar and cannula are inserted

FIG. 6.—Drainage completed.

between the ribs and the cannula remains in place stitched to the skin. Tube connection filled with sterile water is led to a large bottle beside the bed and the end placed under water, thus retaining a vacuum, with a siphon effect. The pus is allowed to escape gradually for the first twenty-four hours by clamping and unclamping the tube. The vacuum is maintained for eight to ten days, when leaking of air around the cannula occurs. At this time the cannula is removed and a rubber tube here illustrated of the same size as the cannula is substituted. This drain cannot slip within the chest and does not protrude so that the dressing presses upon its end. It is well to have two or three of the rubber tubes prepared so that they may be changed. The tubes should not be left out until the cavity is practically obliterated, which can be told by measuring its capacity with water, or by lipiodol and X-ray plates.

Local anæsthesia is always used, even with infants. The intercostal nerves in the space drained, and one rib space above and below are blocked with novocain proximal to the wound. Also one to two cubic centimetres of alcohol are used to block the intercostal nerve of the space drained that the pain from the pressure of the cannula will not trouble for several weeks.

The position selected for the drainage is one rib space below the angle of the scapula and directly below. The space is selected because it is the most dependent portion of the chest with the patient in the reclining position, and also we have found that in chronic empyemas the persistent cavity is at this location and high up along the angle of the ribs. It is important to have the arm to the side when the operation is done. If the incision is made with the arm above the head, the opening in the skin and that of the chest wall will not correspond when the arm is brought to the side.

We are not in a position to say that this method of drainage gives better results in every instance than the open rib resection. Undoubtedly rib resection has a place in certain cases, but we have been better satisfied since adopting this method as a routine. Thus far we have had one chronic empyema resulting, necessitating radical operation. (This case was reported under the deaths.) Two of the series drained for one year and then closed without further treatment. An occasional chronic case we believe may result from any method of treatment. This method can be recommended for its simplicity. It can be done while the patient is in his bed with a minimum amount of operating and slight disturbance to a very sick patient. The closed method of drainage possibly results in some expansion of the lung as the fluid escapes, and does not encourage further retraction of the lung as the open drainage would seem to do. Again osteomyelitis does not occur as is occasionally seen after rib resection. The cannula is non-collapsible, and a suitable tract is left for a large rubber tube when the cannula is discontinued.

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AMYTAL AS AN ANÆSTHETIC IN OPERATIONS FOR GOITRE

THE ORAL ADMINISTRATION OF BARBITURIC ACID COMPOUNDS *

By Harry G. Sloan

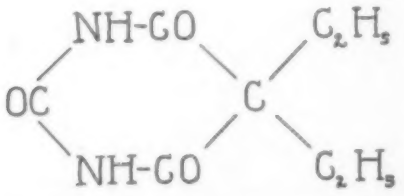
of Cleveland, Ohio

To George W. Crile belongs the credit of first calling attention to the importance of protecting the exophthalmic goitre case from traumatic and psychic stimuli. Trauma can be largely done away with by means of local block and gentle handling of tissue. The psychic factor has been more difficult to master. We now have the answer for this phase of the problem in giving barbituric acid compounds before operation. Our aim in the generalship of these cases has been to give the least insult to the patient's organism as a whole while doing the necessary operative procedure. The barbituric acid compounds offer a real help in controlling the patient's fear during his day of operation.

Given as a draft a couple of hours before operation it makes the day, previously one of anxiety, one of drowsy indifference. There are a number of these compounds varying little in their physiological action and toxicity. Barbital, the earliest of these, was introduced by Fischer and Von Mering in 1904.

The formula:

Barbital



The ethyl groups can be replaced by other alkyl or phenyl radicals to form a large number of derivatives, *e.g.*, when the ethyl group is replaced by the normal butyl group we make "neonal"; when the ethyl group is replaced by the phenyl group we have phenol barbital—luminal, etc. For this series of observations we have chosen iso-amyl ethyl barbituric acid, or amytal. It may be obtained of Eli Lilly & Co.

The use of amytal was brought to our attention in the fall of 1927 while visiting Prof. John Tait's laboratory at McGill University when one of his students, Mr. W. H. Finney, showed us dogs that had been given amytal intravenously. The animals were completely unconscious and deeply anæsthetized. We were told that this state lasted up to thirty-six hours.

* Read before the Cleveland Academy of Medicine, February 21, 1930.

Dogs on which operations were being done gave no indication of pain. We were told that when the anæsthetic wore off the dogs came out of their stupor and returned entirely to normal as far as he was able to discover from any subsequent physical or chemical finding.

The oral use of amytal in the human immediately occurred to us, and on our return we proceeded to investigate its use and any possible harmful effect on man.

1. *Chemistry.*—Amytal, or iso-amyl ethyl barbituric acid, a crystalline powder, is ordinarily dispensed in tablets. It is insoluble in cold water, more soluble in hot, and has a brackish taste which is difficult to disguise. We have given it only by mouth or by rectum. Hot milk, hot water, or tea as suggested by Doctor Sollmann, have been the vehicles used.

Within the hour of taking the dosage we have been using, patients become drowsy and, as the action increases, fall asleep. We have found it to work equally as well when given in hot water by rectum. By the end of two hours the majority are so sleepy that they give no thought to their surroundings. The alert and introspective may voluntarily resist the sleepiness—yet are perfectly tranquil.

2. *Physiological Action.*—There is a fall in metabolism; respiration is increased in rate but has a lesser amplitude; the pulse and blood-pressure are not changed. The body temperature tends to fall. Gastro-intestinal motility is quick under amytal anæsthesia. Blood sugar is not affected. The kidney is not damaged, no pathological elements being found in the urine after its administration, although there are more urates. Bleeding and clotting time are not changed from the normal. There is no change in the CO_2 combining power of the blood.

3. *Method of Administration.*—Amytal or its sodium salt has been given to man in solution by vein. We have been unwilling to inject the drug into a vein, fearing accidents. The drug is unstable in solution. Solutions have to be carefully made. They deteriorate on standing and become cloudy. A deteriorated solution given by vein causes respiratory difficulties, *e.g.*, Cheyne-Stokes breathing. If the undeteriorated solution is given too fast it may cause paralysis of the respiratory centre. When this happens in animals they do not recover (Barlow)—the heartbeat continues until death. According to Eddy the average fatal dose in cats given by mouth is 100 milligrams per kilo of body weight—50 to 60 per cent. of the fatal dose produces surgical anæsthesia. Swanson found 45 to 60 milligrams per kilo given intravenously causes surgical anæsthesia in rabbits, cats and dogs. Zerfas and McCallum report 15 to 20 milligrams per kilo in man given intravenously causes surgical anæsthesia. Man is more susceptible as only one-third to one-half the dosage in animals is necessary for surgical anæsthesia. No lethal dose is known for man.

Our object has been to find an adjuvant to nitrous oxide anæsthesia rather than to obtain surgical anæsthesia by amytal alone. We have thus stayed well within its margin of safety, both in regard to its primary toxicity and

also its morbidity. When large doses are given for basal surgical anæsthesia there is some liability to pulmonary complications due to the prolonged stupor and lack of complete pulmonary ventilation. After oral administration of amytal and morphia it takes much less than the usual amount of nitrous oxide to induce surgical anæsthesia. The patient is very comfortably robbed of the natural anxiety coupled with operation and, furthermore, is in a doze the rest of the day. There is induced in the patient at the same time a marked general analgesia as well as an amnesia.

The cases reported below are from the author's private practice. The diagnosis, operation and after-care claimed his personal attention in each instance.

We experimented with the dosage on exophthalmic goitre cases and after various trials have come to the opinion that it works best when combined with opium, as suggested in a personal letter by Dr. Irving H. Page, of the Presbyterian Hospital, New York. We prefer to give the morphine by mouth as even a hypodermic upsets these patients. The action of amytal resembles that of the general anæsthetics. The heavy and vigorous patients need proportionately larger doses in contrast to the old and feeble who are more susceptible to its action. Our youngest goitre patient was twelve years old, the oldest sixty-seven. Three vigorous men, although they did not remember going to the operating room and were tranquil before operation, went through contortions for one hour afterward. These contortions were slow and orderly, not in the least violent; as, for example, one persisted in taking the knee-chest position—a hypodermic of morphine quickly brought tranquillity. These three instances were the only unpleasant after-effects noted in the series; we have seen no stimulation before operation. Post-operatively they were, with the above exceptions, tranquil and dozy.

Our present dosage is 15 milligrams per kilo—or one grain for each ten pounds of body weight. Eighteen grains has been our largest dose given. Morphine 10-15 milligrams is added and the whole given by mouth as a draft two hours before operation. We have noted that two hours after its exhibition the maximum effect takes place. There is some variation in susceptibility in individuals of the same age and weight. Under ideal circumstances the patient is oblivious to his surroundings. Some may not fall asleep, yet have no memory of what happened. They may be wheeled to the operating room and 75 per cent. of them have no recollection of it.

Amytal makes an ideal preparation for local anæsthesia, *e.g.*, hernia; or, in addition to the amytal, one can do the operation under block and nitrous oxide analgesia.

We prefer to operate on goitre cases under light surgical anæsthesia induced by nitrous oxide and oxygen given after they have reached the height of the effect of the amytal and morphia. In this manner we are able to do away with the mental factor.

Patients may show a slight degree of cyanosis which persists several hours after their operation. Morphia tends to accentuate this.

4. *Impressions After Operation.*—Patients look on it as a boon, in that they are robbed of the anxiety attending their operation. The day of operation is a blank and they have only the kindest memories of a previously trying experience. A number have not been aware that they have been operated on and have asked the following morning when the operation would be done.

We have seen no indication that bacterial immunity is lowered in cases of infection. Patients with heightened blood-pressure do well. Three of our goitre patients have had sugar in their urine previous to operation and post-operatively for several days, then clearing up. In thyrotoxicosis the metabolic rate is reduced. The boon is that very sick patients are more susceptible than usual. In bad-risk patients it is ideal. We have used amytal with the happiest results in the cardiac arrhythmias of thyrotoxicosis. There were several of these. One had previously had three periods of broken compensation before coming to operation—stethoscope apex 138; brachial cuff 100. In another the severity of the intoxication was such that we feared to do more than a ligation. Three weeks previously this patient was delirious—he responded well to Lugol's solution and infusions of saline. His heart was fibrillating badly at the time of ligation—basal rate then plus 61. We did one side at a time under amytal and local block, with excellent results. One exophthalmic, plus 79, who had bilateral cystic kidneys—P. S. P. 30 per cent. in two hours—showed no increase, that we could detect, in kidney damage following operation. We have used it in suppurative cholecystitis in the old in conjunction with nitrous oxide analgesia and local block. The patients have had no pain or discomfort during the procedure, and lay perfectly relaxed and tranquil. In no case have we noted any kidney damage following the administration of amytal. There were four cases where the urine post-operatively showed a trace of albumin when it had been normal before operation. In each instance the specimen showed no albumin the second day after operation.

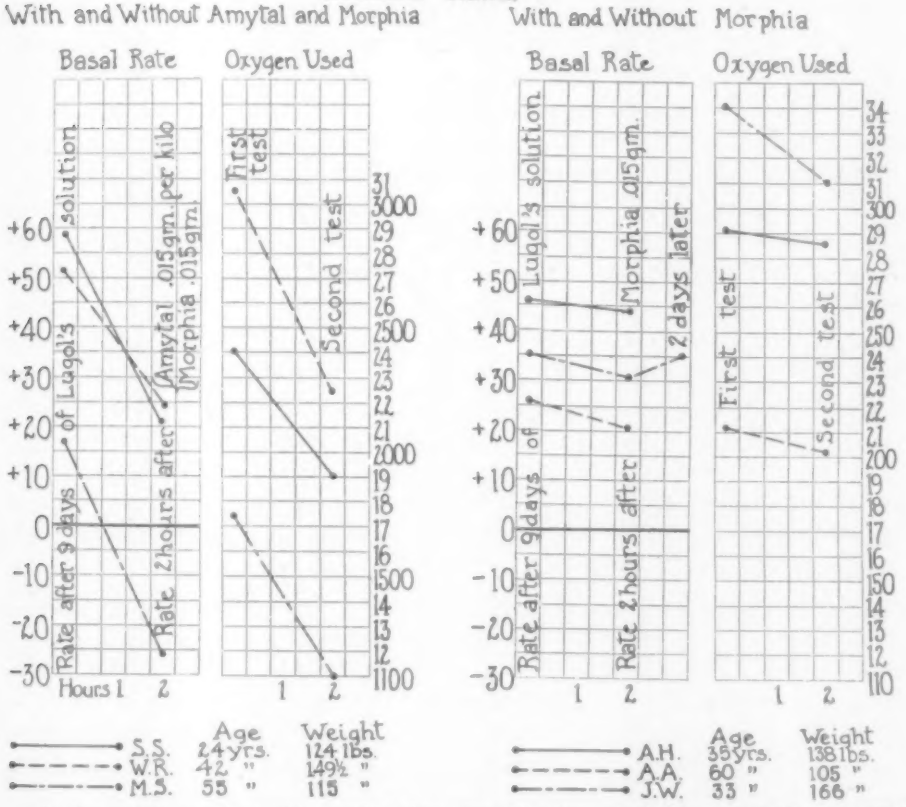
We have tested the effect of amytal and morphia on metabolism in three exophthalmic goitre patients who previously had had Lugol's solution for nine days. Allen Graham has shown, an exophthalmic goitre patient, previously not having had any iodine, reaches his lowest metabolic rate on the ninth day after starting the iodine. We therefore gave these patients iodine for nine days and then tested their metabolism again. Two days later they were given their usual dose of amytal, 15 milligrams per kilo of body weight, plus 15 milligrams of morphine; two hours before the metabolic rate was again determined. There was noticed in each instance a marked drop—plus 52 to plus 24; plus 17 to minus 26; plus 59 to plus 21—more than 50 per cent. They were taken immediately after their metabolic test to the surgery where they were operated upon. This drop in metabolism we think is a very beneficial effect of amytal in exophthalmic goitre patients. Denel, Chambers and Evergen have shown in animals that it persists for five or six hours. See Table I.

Under this dosage of amytal and morphia we noted a decrease in the amplitude of the respiratory excursion and an increase in the respiratory rate.

Three other cases who had likewise been iodized were tested after having been given only morphine gm. .015 by month two hours before. They also showed a drop in their metabolic rate—plus 45 to plus 41; plus 26 to plus 21; plus 35 to plus 31. We tried in this way to determine the action of amytal and morphine when compared to morphine alone when given under the same conditions. Under morphine alone we noted a slowing of the respiratory rate with an increase in the depth of the excursion.

TABLE I

Comparative Basal Metabolic Rates
(Iodized Gland)


With and Without Amytal and Morphia
Basal Rate
Oxygen Used
Rate after 9 days of Lugol's solution
Rate 2 hours after Amytal .015 gm. per kilo (Morphia .015 gm.)
First test
Second test
Hours 1 2
With and Without Morphia
Basal Rate
Oxygen Used
Rate after 9 days of Lugol's solution
Morphia .015 gm.
2 days later
First test
Second test
Age Weight
S.S. 24 yrs. 124 lbs.
W.R. 42 " 149½ "
M.S. 55 " 115 "
A.H. 35 yrs. 138 lbs.
A.A. 60 " 105 "
J.W. 33 " 166 "

In the second case done with morphia alone, two days later metabolism was again determined without morphia and had returned to that of four days previously.

Our routine procedure in exophthalmic goitre patients is as follows:

They are told they will be operated on when their condition is favorable, and the subject is not further discussed. We have found they stand this uncertainty better than to know the time set for their operation. They are in hospital several days before operation. We plan to do the operation on the ninth or tenth day of their iodinization, when their metabolic rate reaches its lowest point, if they previously have had no iodine medication. All our

thyrotoxic cases receive iodine before operation whether the anatomical lesion is a hyperplasia or adenoma. We prefer to operate early in the morning—so, on waking, they are given the draft of amytal and morphia. No preparation is made of the operative site nor is there any change of clothing. They are so drowsy at their usual breakfast time that the withholding of the meal passes unnoticed. Two hours after having the amytal they are gently wheeled in their beds to the operating room. The tactful nurse in attendance has in the meantime covered their eyes with a piece of moist gauze. Silence of the attendants is maintained and any sudden jolts to the bed in its transit, as well as extraneous noise, avoided. The anæsthetist awaits their arrival in the operating room, mask in hand, with a gentle flow of nitrous oxide running. The patient is not touched nor spoken to while the anæsthetist gradually lowers the mask into place. After a minute the mask touches the face, is clamped in position, and the patient is ready to be placed on the operating table. When the whole procedure goes through with finesse we expect to have the anæsthetized patient on the table with the same pulse rate and blood-pressure of the day before while in bed. In this manner they are operated on under surgical anæsthesia where we are able to control our asepsis. They are then put back in their bed and wheeled to their room. So the drowsy day goes on.

In several instances we have done the thyroidectomy under amytal and local block. The tranquillity of the patients was marked in its contrast to the agitation seen when only morphia and local block are used.

The nurses emphasize the tranquillity following operation in comparison with goitre patients not so managed. All drowsy effect disappears by the next morning. We have seen no stertorous respiration following operation as our dosage is not sufficient to cause deep stupor. No patient vomited more than three times after operation, and usually only once. Nausea occurred after operation in 20 per cent. of the cases. It is our feeling that this is directly dependent on the severity of the disease and the nitrous oxide added. On return to the ward we found the rectal temperature had already started to rise as is usual following operation in thyrotoxicosis. In other than thyrotoxic cases the post-operative temperature is a fraction of a degree lower just after operation and comes up to normal in one to two hours.

In reviewing an equal number of goitre operations done by the author, the sequence immediately preceding this group under the same technic in equally severe types of disease but using morphia and atropine as a pre-anæsthetic medication instead of amytal and morphia, we noted:

Amytal and Morphia	*Morphia and Atropin*
No. cases—60	No. cases—60
Diagnostic B.M.R. plus 48	Diagnostic B.M.R. plus 42.6
Highest rectal post-op. T° 38.86	Highest rectal post-op. T° 38.76
Highest post-op. pulse 127	Highest post-op. pulse 132
B.P. Bed day before 137/78	B.P. Bed day before 146/74
B.P. Anæs. on table 142/81	B.P. Anæs. on table 162/83
Pulse rate in bed 94	Pulse rate in bed 98
Pulse rate on table 106	Pulse rate on table 127

In 20 per cent. of this series we have failed to put the anæsthetized patient on the operating table with the same pulse and blood-pressure reading as the day before while they were in bed. In doing this we must bear in mind the explosive nature of the disease with which we have to deal. Also there is the factor of changing house staff and nurses as well as the varying susceptibility of patients to the drug, as well as our experimental dosage in the series. With the perfection of the method and adequate dosage we expect our next series to show marked improvement over this percentage.

The advantages of amytal in connection with thyroidectomy amount to this: We are able to remove the patient's gland more artfully, with less mental jolt, and the day of operation, formerly remembered as a nightmare, is robbed of its terror.

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TRANSPLANTATION OF THE URETERS

FOR CANCER OF THE BLADDER WITH CYSTECTOMY

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The bladder is the last of the more important removable organs to be brought into the legitimate surgical field for the radical treatment of cancer. Beginning with carcinoma of the uterus, stomach, large intestine, rectum and lastly the bladder, the operation for removal of each of these organs has, in its turn, passed through a stage of empiricism and uncertainty as to its real value. The final standardization of surgical procedure for the treatment of cancer of each of these organs has been consummated largely by careful study of the lymphatics and blood-vessels of the organ involved.

A vital consideration which has delayed development of radical surgery of the bladder beyond that of other organs has been the lack of a satisfactory method for disposal of the ureters. Prior to the solution of this problem, the feasibility of the operation has been so questionable that there has been very little incentive to work out a technic. Nevertheless, some definite plans have been evolved for removal of the bladder, notably that of Albarran [1] and later the one submitted by Beer.[2] Both of these operators, however, have gone no farther than to bring the ureters to the surface, at the most convenient place, after the bladder has been removed. Eliminating the few hundreds of sporadic cases, more or less, which have been reported in the literature as having been performed without any very definite plan, with an operative mortality of more than 50 per cent. we may consider the recent development of the operation of cystectomy under four headings or plans as regards the disposition of the ureters:

First, systematic removal of the bladder by a definite plan in which, after removal of the bladder, the ureters are brought to the surface in some definite way. In this, Beer [2] seems to have been more successful than others. Secondly, a systematic plan for removal of the bladder for cancer after the ureters have been transplanted at two separate operations by the submucous technic described in 1909 [3] and 1910.[4] In this plan, removal of the bladder constitutes a third major operation. Lower [5] apparently has tried this plan more fully than any other surgeon and has found it unsatisfactory. While I brought out this method of transplanting his ureters, I have never felt at any time that this second plan was feasible for the treatment of cancer of the bladder. For this reason, I set about to perfect a third method by which both ureters could be transplanted simultaneously. This was accomplished by using large inlying catheters, the final technic of which was described in *Surgery, Gynecology and Obstetrics*, November, 1928, under the

title: "Transplantation of the Ureters into the Large Intestine."* Detailed report of the clinical results of this operation was recorded in the *Journal of the American Medical Association*, November 16, 1929, under the title: "Bilateral Submucous Transplantation of Ureters into Large Intestine by Tube Technic." In this series, twenty cases were reported with one operative death. Of these, transplantation had been performed for cancer in eight cases (2, 5, 6, 7, 8, 13, 14, 19), without operative death. Of the eight cases, three (2, 7, 8) had extensive metastases in other parts of the body and transplantation was done entirely as a palliative measure. Of the remaining five cases, three (6, 13, 14) had local extension to such a degree that removal was thought impossible. In these cases, the ureters were transplanted and radium in destructive doses was used. In one of these cases (6), the bladder seemed to have been destroyed and the growth locally cured by the radium, but the patient died a sudden death seventeen months after operation, seemingly from some form of thrombosis. As the patient was living in a remote mountainous district, no post-mortem could be obtained. In Case 13, the growth infiltrated the base of the bladder and extended to the deep pelvic fascia. Massive dosage of radium was used which for a time reduced the growth and slightly reduced the pain though only temporarily. Then the growth took on very active development and the patient died nine months after operation with extensive metastases in the liver as well as extension of the local growth. In the other case (14), the growth was extensively treated by radium applied directly to the growth. After the first dose, the growth seemed to diminish but it soon recurred and began to grow actively. After the second attack upon the growth by radium, no effect was noticed and four and one-half months after the transplantation operation, the bladder was destroyed with a cautery. Within six weeks, transplants, cytologically similar to the original growth, appeared all over the cavity of the wound. Patient died fifty-four days after the cauterization from the exhaustion produced by the fulminating recurrent growth. This left two operable cases (5, 19), in one of which there was a very large infiltrating growth extending down to the neck of the bladder. In both cases, extensive dosage of radium was used in the bladder after the transplantation.

In one case (5), in which the growth had returned, following microscopic examination and radium treatment a year before, the ureters were transplanted on July 3, 1928. A large dose of radium was used on August 4, 1928, and total cystectomy was done September 20, 1928, at which time the bladder showed extensive fibrosis resulting from the radium but no active cancer was found in the microscopic sections examined. The patient has remained entirely well up to the present time, twenty-two months after the ureters were transplanted.

In Case 19, 6000 milligram hours of radium were used in the open bladder directly against the growth, with the result that the growth almost disap-

* The previous preliminary presentation was published in *Northwest Medicine*, May, 1925.

peared, but leaving a small open ulcer which would not heal. It was thought wise to do a total cystectomy which was performed November 26, 1929. This patient had a stormy convalescence from the last operation as a result of what seemed to be a low-grade infection around the pubic arch. As the patient recovered and was ready to leave the hospital, examination through an opening in the vagina showed that the public bone was bare and that the

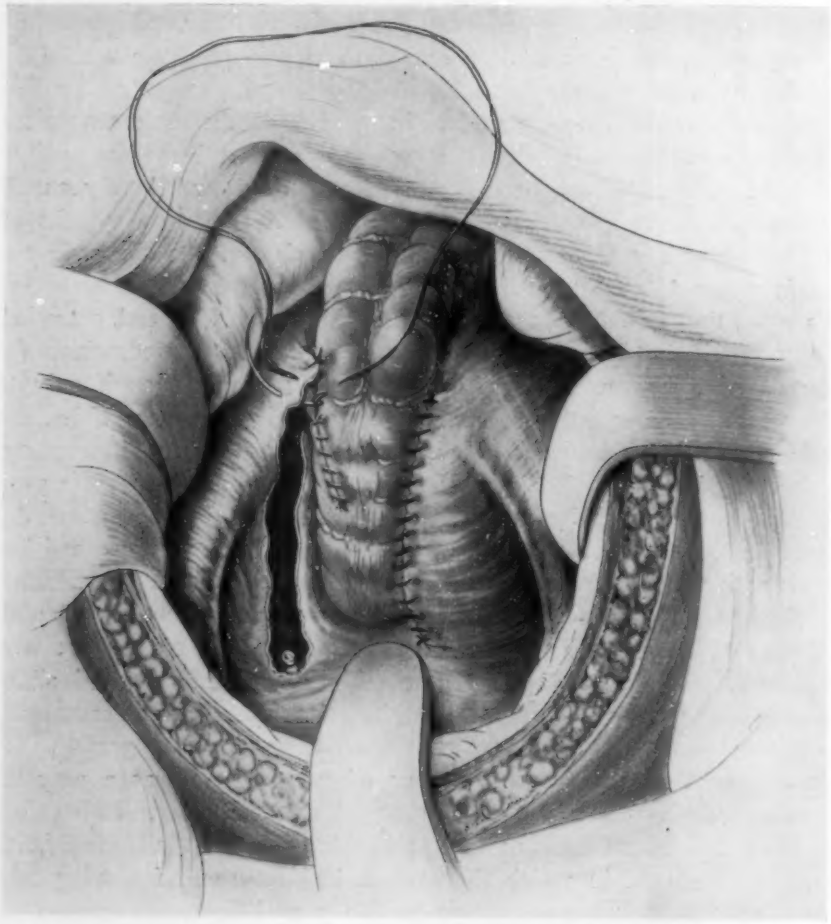

FIG. 1.—Ureters have been transplanted and the peritoneal edge forming the outer margin of the slit from which the ureter has been elevated, is being sewed over the ureter and the line of intestinal suture. This gives potential retro-peritoneal drainage to the field of the bladder operation.

cartilage of the symphysis pubis had disappeared leaving space between the ends of the pubic bones. Fortunately, fibrous ligaments at the upper and lower margins of the pubic bone had developed to such an extent that there was no mobility. Patient left the hospital with good locomotion, in good condition, and was apparently cured of the cancer. I believe the injury to the bone and cartilage was caused by the large dosage of radium.

To the report of these two cases of cystectomy for cancer preceded by

bilateral transplantation of the ureters, may be added two more cases by this method which have been reported to me in personal communications by Dr. Frank Lahey, of Boston, and Dr. W. L. Estes, Jr., Bethlehem, Pa. Both surgeons express themselves as highly satisfied with the results.

I believe that bilateral transplantation of the ureters by the tube technic, with removal of the bladder by a second operation a few weeks later, constitutes a marked advance in the radical treatment of cancer of the bladder. However, there are certain drawbacks to the two-stage plan:

1. The cancer is growing during the interval between operations.

2. The intraperitoneal drainage and convalescence from a four or five weeks' illness plus the adjustment of the renal function to the new location

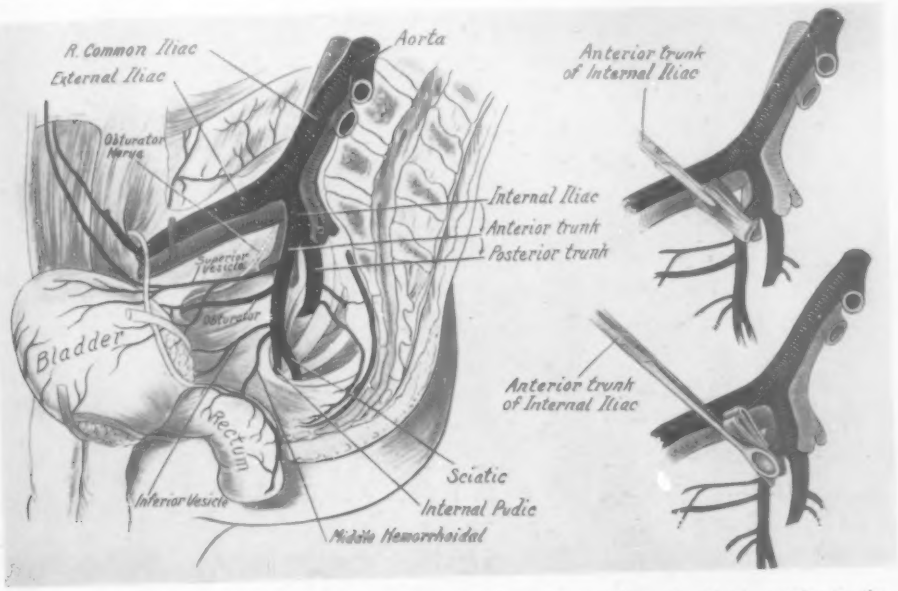

FIG. 2.—Adaptation of a figure from Gray's Anatomy to show the blood supply to the bladder. The two figures to the right show how the anterior trunks of the internal iliacs which supply practically all the direct blood supply to the bladder may be temporarily obstructed while the operation is performed.

of the ureters, is not a perfectly ideal point from which to start a cystectomy operation.

3. The wound for the cystectomy must be made through a recent operative field and such a wound is usually cramped for size, making the operation difficult.

The advantages of performing the cystectomy at the same time the ureters are transplanted are obvious:

1. The growth is obliterated at once, and its progress thereby stopped.

2. The drainage may be made entirely extraperitoneal.

3. The large wound which has been made for double transplantation of the ureters makes the operation of cystectomy much easier than when it is done through a special cystectomy wound, for besides the ease of manipulation, the blood supply may be easily located and absolutely controlled. There

is no blood lost and practically no additional shock follows as a result of the added operation.

4. There is one operation, one siege of drainage and one convalescence instead of two. The time in the hospital is less than half that of the two-stage operation.

Steps of operation.—A long abdominal incision is made to extend above

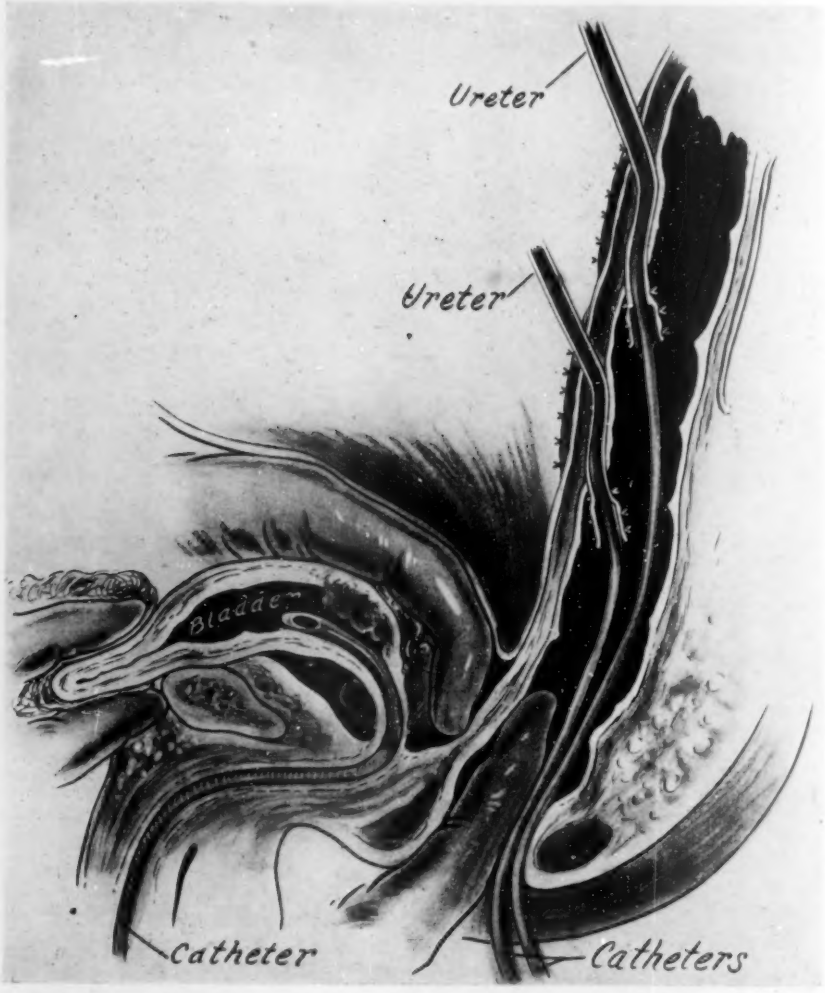

FIG. 3.—Mobilization of the bladder by the fingers has just been completed, including the vesiculæ seminales and the prostate. The catheter which has been used both to drain the bladder and inject it with alcohol is still in place. An assistant's finger is in the rectum as a guide.

and slightly to the left of the umbilicus. The kidneys are carefully palpated to determine their physical condition with particular reference to hydronephrosis. The transplantation operation is performed by the exact technic described in *Surgery, Gynecology and Obstetrics*, November, 1928, including the preliminary cleansing and the drying of the large bowel with gauze packing. After the transplantation wounds in the intestine have been closed,

the edge of the cut pelvic peritoneum forming the outer margin of the slit through which the ureter has been lifted is drawn over and sutured to the intestine so as to form an extra covering for the line of sutures which bury the ureters and thereby make the wound in the intestine extraperitoneal. But, instead of leaving the line of suture incomplete as a drainage opening at the lower end of the peritoneal slit which leads into the retroperitoneal space, the peritoneal wound is entirely closed (Fig. 1). This retroperitoneal space on each side of the pelvic colon connects with the space from which the bladder has been removed, giving ample retroperitoneal drainage. This obviates the necessity of passing drainage material through the peritoneal

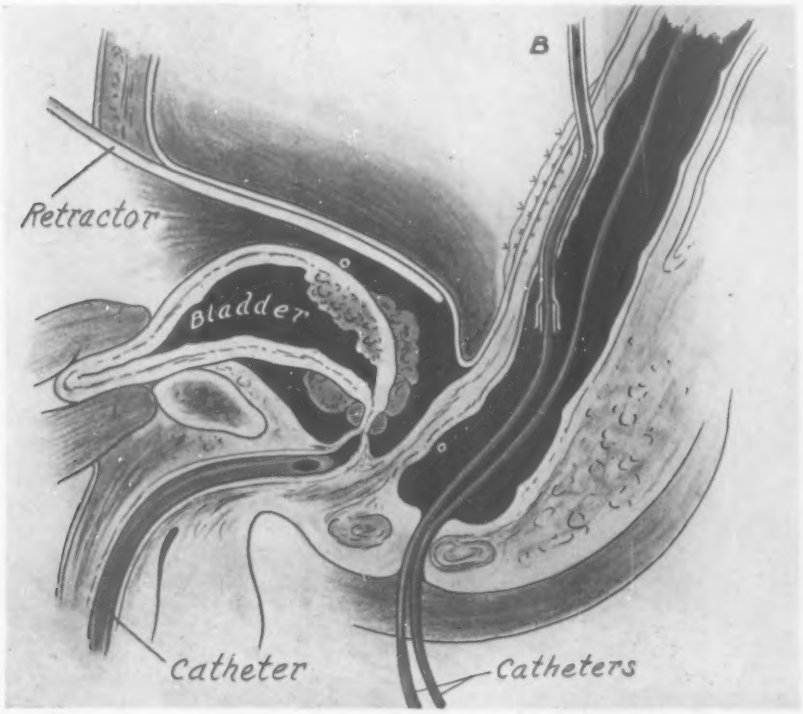

FIG. 4.—The catheter has been slipped outward while an angle forceps clamps the prostatic urethra. In a moment the urethra will be cut just below the clamp, and the bladder removed intact with its neck closed.

cavity. As soon as the intraperitoneal suturing is completed, the deep pelvis is temporarily packed with sterile gauze to prevent contamination during the cystectomy operation which is to follow. A large size catheter is inserted into the bladder through the urethra to drain off any fluid that may be in it. As a precaution against possible cancer transplant in case the bladder is opened, inject the bladder full of alcohol and clamp the catheter and leave the alcohol until actually ready to mobilize the bladder. With the fingers inserted beneath the parietal peritorenum at the lower end of the central incision, the peritoneum is separated from the abdominal wall until the iliac vessels come into view. The anterior trunks of the internal iliac arteries, which furnish practically all the direct blood supply to the bladder, are easily

located and obstructed. This obstruction may be either temporary or permanent. Temporary obstruction may be produced by passing a broad rubber band around the trunk of the anterior internal iliac. An ordinary loop sponge holder placed on the artery outside the rubber completely obstructs the direct blood supply to the bladder (Fig. 2).

Manipulations for removing the bladder are now begun by separating the bladder muscle from its peritoneum. This is easy except at the very top of the bladder where it may be necessary to separate the structures with scissors, although this is not usually the case. The fingers then separate the

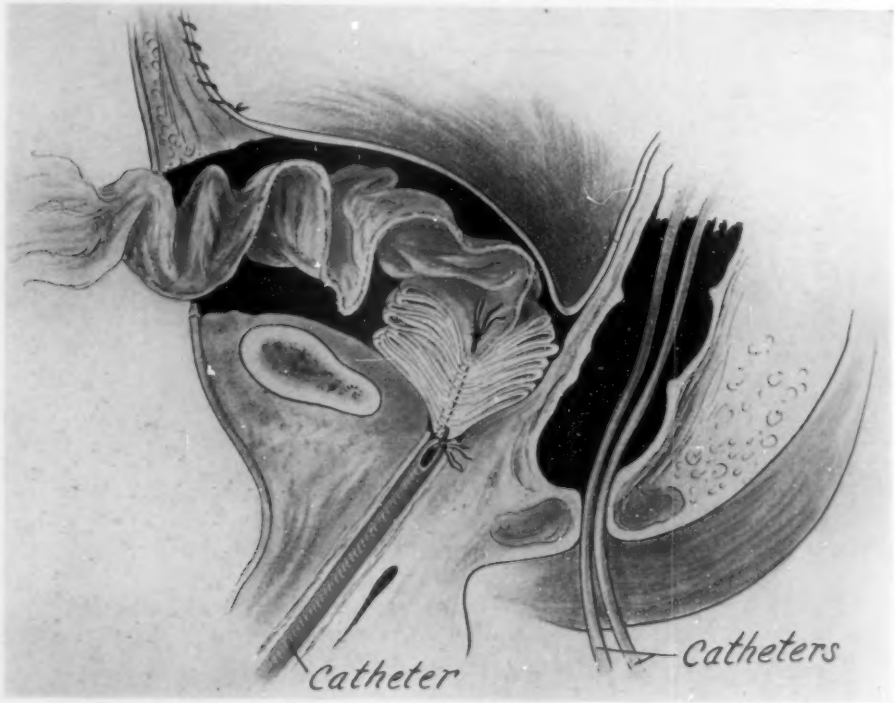

FIG. 5.—The catheter has been passed into the bladder space and attached to the lower fold of a specially prepared gauze pack. An assistant has pulled on the catheter from below until the gauze pack is wedged tightly in the space from which the prostate and vesiculæ seminales have been removed. The vesical space is being lightly packed with gauze. The peritoneum as it follows the abdominal wall has been closed leaving the gauze in the extraperitoneal or vesical space.

bladder from the pelvic wall, bringing up some of the extra-vesical fat with the bladder. Little cords appear in the fat. These are the vessels which supply the bladder. They are clamped and cut, and separation proceeds without loss of blood. About this time, the alcohol is allowed to escape from the bladder through the catheter. An assistant, with a piece of gauze in the fingers, now picks up the fundus of the bladder and draws it forward and downward. The vasa deferentia come into view and are ligated and severed. The ureters have already been ligated and severed and their stumps are hanging to the base of the bladder. An unclean assistant is then asked to insert one or two gloved fingers into the rectum as a guide to the operator while he mobilizes the vesiculæ seminales and prostate (Fig. 3). The lateral

ligaments of the bladder are clamped and cut on the bladder side. The vesiculæ seminales are easily separated from the rectum with the fingers and soon come into view. The bladder is now separated from the pubic bone by clamping and cutting the pubo-vesical ligaments. Upon lifting up the prostate there is a certain amount of passive bleeding from the prostatic plexus notwithstanding the obstruction of the anterior iliac arteries. This bleeding may be controlled by packing a little gauze into the space while the operation continues. It is possible, and may in some cases be advisable, to transfix the prostate and ligate it after the plan of Watson and Cunningham [6] or Beer [2]. It is just as easy and probably better, however, to remove the prostate with

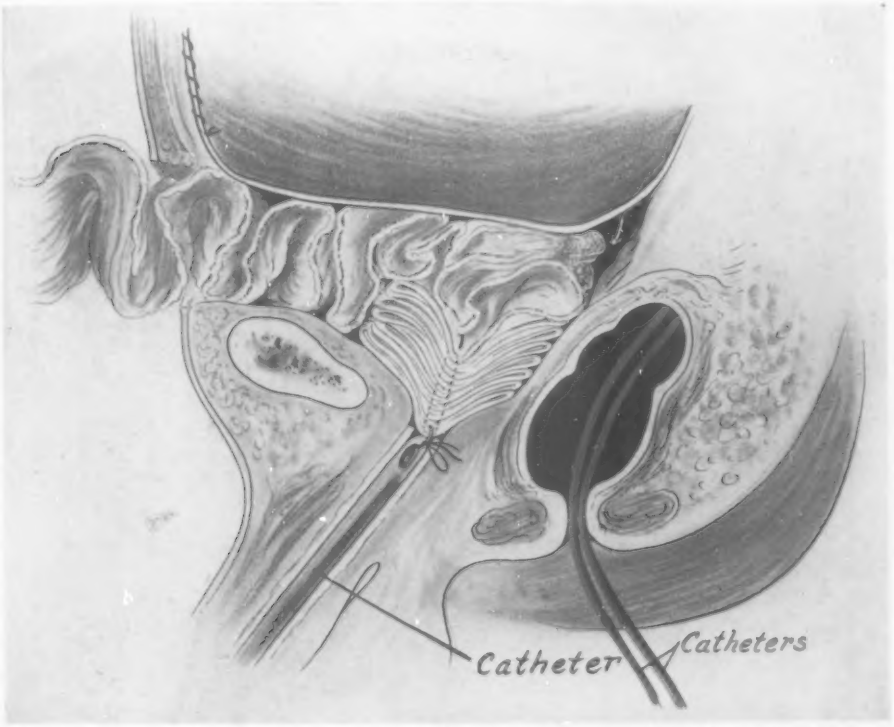

FIG. 6.—The arrow indicates drainage which might conceivably come down in the retroperitoneal space from the site of the operation.

the bladder. As soon as the prostate and bladder are completely mobilized and hang by the urethra as a pedicle (Fig. 3), the catheter within the bladder is withdrawn so that its tip is back in the urethra. An angle clamp is placed across the lower end of the prostatic urethra (Fig. 4). The urethra is severed just below the clamp, the bladder is removed, the catheter is pushed in and attached to a previously prepared gauze pack * by fastening together the

* A gauze strip, twelve inches wide and ten feet long, is folded to four thicknesses, edges inside. This makes a ten-foot tape. Beginning at one end, this tape is folded back and forth like the folds of a fan until 8 or 10 double folds have been made into a pack. From the proximal side a heavy quilt suture is passed through the pack and back, and then tied firmly, leaving the ends at the knot an inch long (Figs. 5 and 6).

distal fold of the pack and the end of the catheter with a strong suture. An assistant then draws on the urethral catheter from below and draws the pack into the bed from which the prostate and vesicles have been removed (Fig. 5). This completely controls the passive hæmorrhage. The thighs are then brought together by a wide band of adhesive plaster which is placed around them. To this band, the end of the catheter is fastened under tension so as to hold the pack in place until all danger of bleeding has passed. The vesical

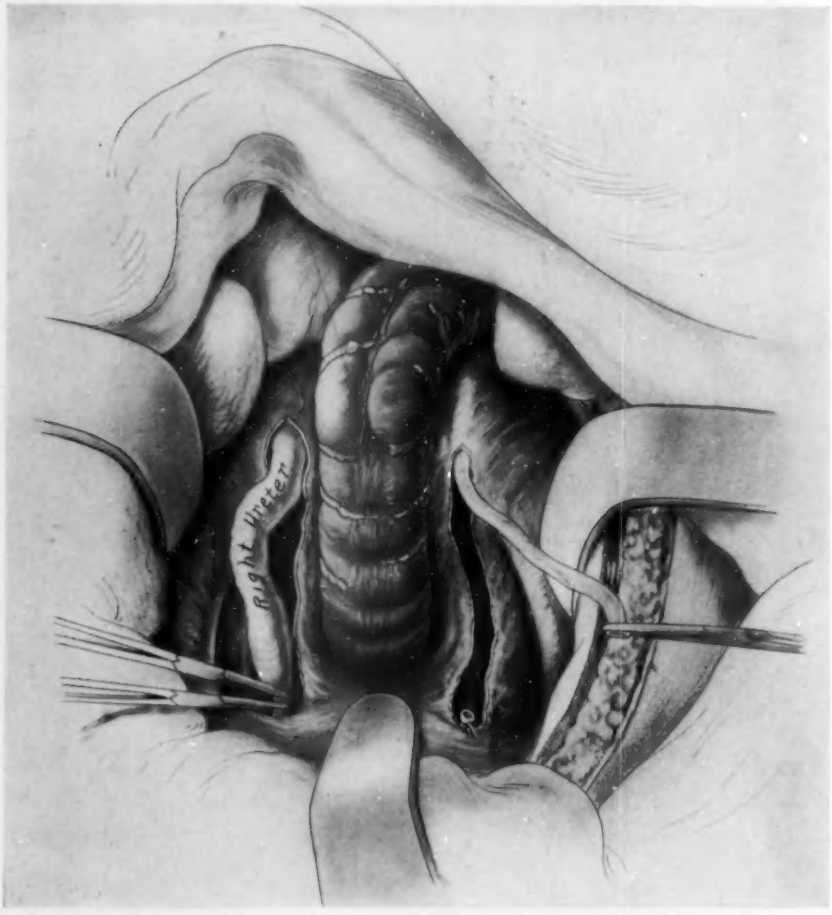

FIG. 7.—Right ureter enormously dilated as result of passing through the growth.

space is then lightly packed with the remainder of the gauze strip. The obstruction may now be removed from the anterior trunks of the iliac arteries. The retroperitoneal space on either side of the rectum communicates with the vesical space and therefore is amply drained (Fig. 6). It is interesting to observe that after the bladder is removed, the obturator nerve is lying exposed and if irritated by packing makes pain on the inside of the thighs where the nerve supplies the adductor muscles. The abdomen is closed and the operation is complete.

It has taken little more than fifteen minutes' extra time to do this complete bloodless and shockless cystectomy and we have the great advantage of having the growth out, the drainage entirely extraperitoneal and no more operation to be done.

The tension may be taken off the urethral catheter in twenty-four hours or so. The gauze may remain a week without trouble and is then removed under light gas anæsthesia. The gauze strip may be withdrawn until the proximal side of the pack approaches the opening. The external superfluous end of the catheter having been cut off, the remainder follows the gauze. The knot of the quilt suture is now cut and the pack unfolds as the strip is withdrawn (Fig. 7).

Fig. 8.—Bladder specimen laid open through posterior wall showing the growth involving the right ureteral opening.

I have had the opportunity to do one operation by this technic. A brief report of the case follows:

Case Report.—C. E. R., male, poultry farmer, age fifty-nine. He had a history of having had blood in his urine off and on for about three years. On December 12, 1929, he began to have severe pain in the right kidney region. This persisted until the latter part of January when he began passing clots of blood. This bleeding continued. A diagnosis of cancer of the right side of the bladder had been made by a urologist. He entered our clinic March 12, 1930, and the diagnosis of cancer was confirmed. As he was having a great deal of bleeding and a great deal of pain, he was advised to have it operated upon with the understanding that he would probably have his bladder removed and the ureters transplanted into the rectum. He went home to arrange his affairs. During these few days at home he had an alarming hæmorrhage from the bladder. A doctor was called to give him relief. At the time he first consulted us, he had a hæmoglobin of 96; blood-pressure 170/100; urine showed blood and pus but otherwise was normal. He returned and entered the hospital March 20, 1930, with a hæmoglobin of 66. A blood transfusion was given. On the 22nd, his hæmoglobin was 78. He was operated upon March 22, 1930, at which time the operation described above was performed. At that time it was observed that there was a cancer of the bladder 1½ inches in diameter involving the right ureteral opening which also infiltrated the bladder wall. The right ureter was dilated to the size of the index finger (Fig. 7). The pelvis of the right kidney was correspondingly dilated

and hydronephrotic. The left ureter was thickened but only slightly dilated. The left kidney appeared to be normal. While the patient was not greatly shocked, his hæmoglobin was low and it was decided to give him another blood transfusion at the close of the operation. He left the operating room with a pulse of 76, full and of good quality.

Progress.—The temperature the day before operation was 102° and remained so until two days after the operation. After this, the temperature during convalescence ranged from normal in the morning to 99° and 100° in the afternoon. During four days the temperature went as high as 101° in the afternoon and the pulse was over 100 on five separate days during the convalescence. At no time did the patient present the appearance of being seriously ill. The total output of the left kidney during the first thirteen days was 16,985 cubic centimetres, while the output from the right hydronephrotic kidney with a dilated ureter, was 3,467. By the phenolphthalein test, the dye occurred in the left kidney in six minutes and in the right kidney in twenty minutes. This delay in the right kidney, however, may have been due to the larger capacity and the less secretion of the right kidney which required a longer time to reach the end of the catheter from the kidney pelvis. The function in this dilated kidney is in accordance with our former observation in cases where the ureter has been enormously dilated at the time of operation. In all such cases, the kidney is correspondingly damaged and apparently never entirely recovers. During the thirteen days that the catheter remained in so that comparison could be noted, there was no change in the relative output of the two kidneys. At the end of eight days, the gauze pack was removed from the bladder space and was lightly repacked with sterile gauze. A week later the packing was again changed without anæsthetic, wound held open by retractor, lighted with Cameron lights and wound inspected inside. This was done again in six days, at which time the wound was washed out very carefully and a beautiful granulating cavity was exposed and inspected. This has gradually closed. There was never at any time the slightest pain or discomfort in the region of either kidney. Patient's appetite has been fairly good and it may be said the patient made an uneventful recovery, has gone home and is seemingly entirely well.

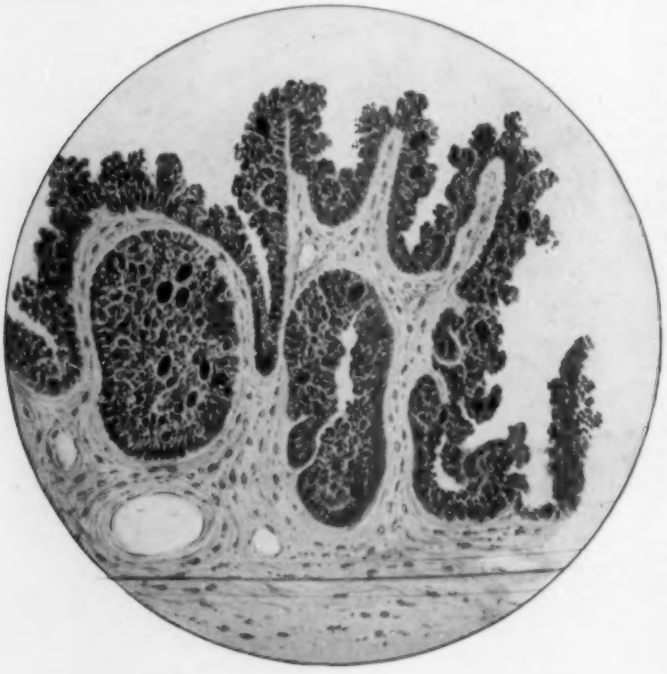

FIG. 9.—Microscopic section of growth.

CONCLUSIONS

1. If a satisfactory reservoir for urine can be safely established and a safe removal operation can be performed, cystectomy becomes the ideal treatment for cancer of the bladder.

2. Cystectomy, no matter how safe nor how curative in its results, which provides no satisfactory reservoir for the urine, is at best a disagreeable makeshift and will never become a popular operation.

3. The fundamental necessity in performing cystectomy is that a muscular reservoir controlled with a sphincter must be provided.

4. The physical problem to be solved in performing this feat is the delivery of the output of a secreting organ in which the pressure is low and regular into a muscular reservoir where the pressure is high and irregular. In physics this can be accomplished only by the use of the valve principle.

5. In the animal mechanism, nature has invariably produced a valve for such purpose by running the delivery duct of the organ between the mucous

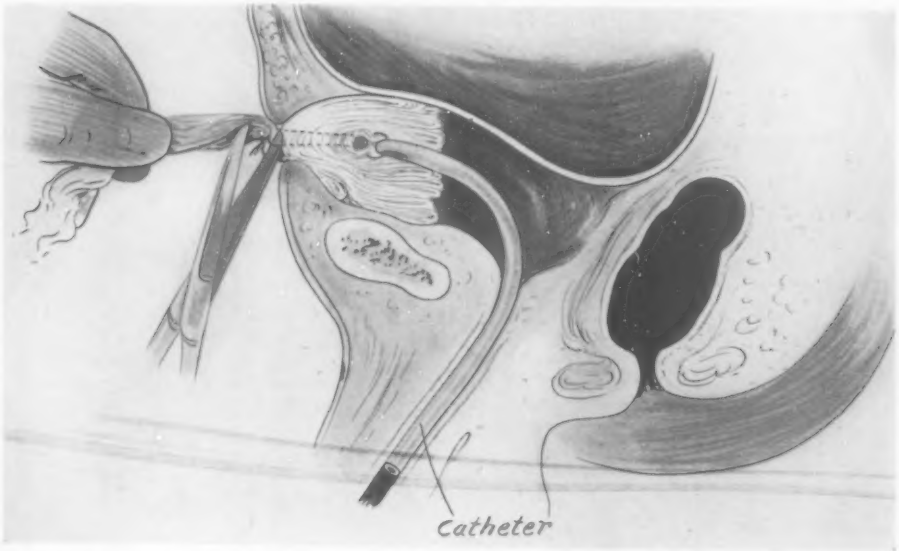

FIG. 10.—Gauze pack is pulled up into the wound and knot is being cut to permit its unfolding.

and muscular coats of the reservoir for a distance before emptying the duct. Surgical transplantation of the ureter involves this principle.

6. Three plans for submucous transplantation of the ureters have been developed (Fig. 10).

Plan A.—Split end of the ureter is dragged through a stab wound in the mucous membrane at the lower end of a long incision which severs all the tissues down to the mucosa. The end of the ureter is anchored inside the intestine and the ureter above the opening is buried between the mucosa and muscularis with sutures. This plan includes the fundamental valve principle. Clinical results have proven conclusively that in those patients who survive the operation, the valve thus formed is ample to protect the kidney against intra-intestinal pressure and infection from the bowel. The drawbacks to this plan are: 1. The open end of the ureter is exposed in the bowel.

2. Opening the mucous membrane of the bowel exposes the wound in the intestinal wall to immediate infection, which often produces a profound reaction during convalescence and sometimes results in death. The resultant swelling temporarily obstructs the ureter and makes bilateral transplantation inadvisable. The obvious necessity of three dangerous operations, one for

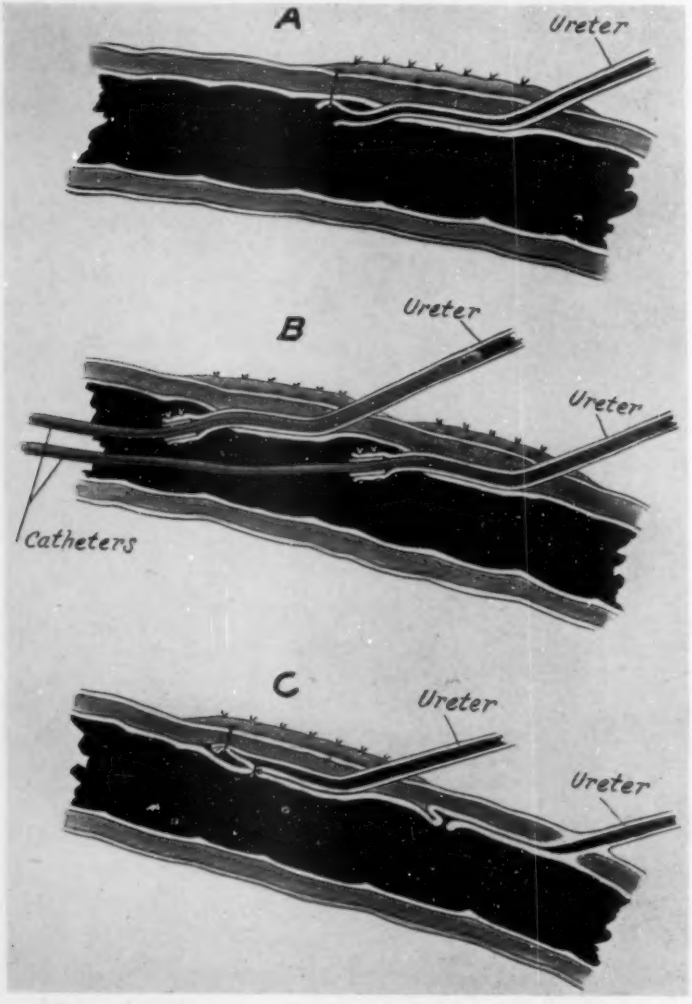

FIG. 11.—Three plans for submucous transplantation of the ureters.

each ureter and one for the cystectomy, automatically eliminates Plan A from the operation of cystectomy for cancer of the bladder.

Plan B.—Bilateral transplantation of the ureters by the tube technic. This plan is far more complete and offers decided advantages. Great care and rigid technic for cleansing and drying the bowel is exercised in order to cut down the chance of contamination of the intestinal wound during the operation. A large catheter is placed in each ureter and the ureter is firmly

tied around the catheter where it is anchored to a soft rubber cuff. By keeping the ends of the catheters in bichloride of mercury solution, there is no possible way in which infection may ascend directly in the lumen of the ureter until the ends of the ureters slough and the catheters come away, which is usually from ten to twenty days. Renal function is in no way disturbed by this operation. Both kidneys function normally throughout convalescence. An enormously dilated ureter may be transplanted by this technic. In spite of extraordinary precautions in cleansing the bowel, there must be a certain amount of infection in the implantation wound of the bowel wall in any operative technic which opens the intestinal mucosa.

That the infection is less by Plan B than Plan A, is shown by the fact that it is far safer and convalescence is much less stormy with the transplantation of two ureters than follows the transplantation of a single ureter by Plan A.

A drawback which applies to the general adoption of Plan B as well as Plan A, is that the operation is far more serious in the dog than in the human being, probably due to the greater virulence of the intestinal bacteria in the dog. Therefore, the surgeon is handicapped in perfecting a technic by animal experimentation. Many surgeons, who would otherwise be interested in the operation are discouraged by the animal experimentation. The overwhelming concrete advantage of Plan B is that by using this plan it is possible and practical to do the complete operation of cystectomy at one sitting without drainage through the peritoneal cavity.

Plan C.—(Fig. 11.) Four years ago while conducting a series of animal experiments for the purpose of perfecting the tube technic, the observation was made that when one of the sutures which anchors the ureter in the intestinal wall transfixed the ureter and also the mucous membrane, a permanent uretero-intestinal fistula resulted. Later the query arose "How much time is required for the transfixion suture to cut through and make an anastomosis?" This was answered by a few experiments which showed that the urine appears in the intestine within twenty-four to forty-eight hours after the transfixion suture is placed. With this information, a technic for uretero-enteric anastomosis without immediately opening the intestinal lumen was developed.

Of seven single ureters experimentally transplanted in this way, there has been no evidence of kidney infection. The clinical recovery of the animals is incomparably better than by any previous method. The urine appeared in the intestine from twenty-four to forty-eight hours invariably, except in one case in which the transfixion suture was not tied very tightly. In this case the appearance of the urine was only sixty hours after transplantation. In cases where post-mortems have been done, there has been no peritonitis. At the end of a week, whereas by all former methods there was manifest infection in all intestinal wounds, in these cases there was no evidence of infection. The ureter was not dilated and there was no evidence of pus in the kidney pelvis. There was, however, some congestion of the

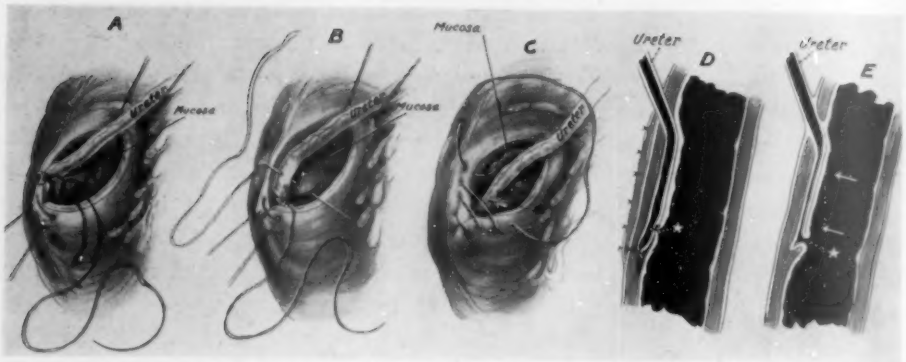

FIG. 12.—Transfixion suture technic for making a uretero-enteric anastomosis. A—End of ureter has been transfixed and ligated with oo chromic catgut suture, doubled. Needle has passed from within out on one side and from without in on the other side and the end of the ureter is tied into the lower angle of the wound between the mucosa and muscularis. B—The end of the ureter is anchored in the angle of the wound with a catgut suture. A fine needle carrying strong fine linen or silk thread, doubled, transfixes the ureter about its middle and picks up the full thickness of a quarter inch fold of mucous membrane of the intestine. C—The muscular and peritoneal wall of the intestine is being drawn over the transfixed ureter. Interrupted fine linen sutures add additional safety. D—Sectional view of transfixion operation. Star shows transfixion suture. E—Final results of anastomosis by the transfixion method. Star indicates opening.

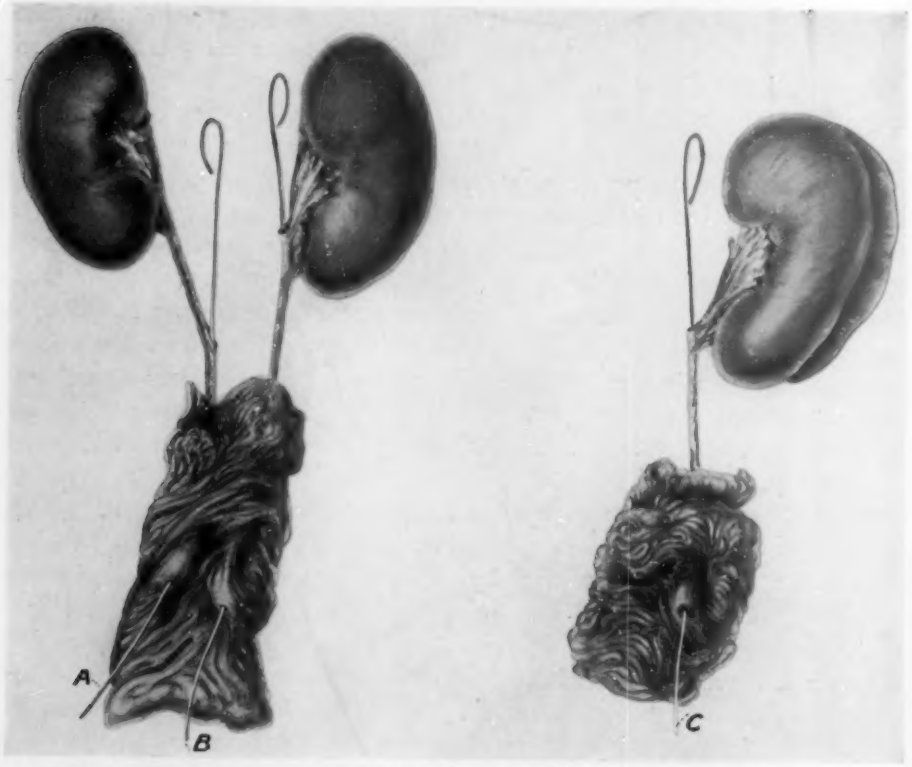

FIG. 13.—Post-mortem specimens: A—One week old anastomosis showing result of transfixion suture anastomosis of right ureter of dog. B—Four weeks old anastomosis in same dog, left ureter. C—One week old anastomosis in another dog, left ureter. Note the clean-cut opening which has been made in each instance by the transfixion suture and freedom from sloughing or other evidence of infection.

capsule of the kidney, probably due to temporary obstruction as shown by the fact that in cases where the post-mortem was done four weeks after transplantation, the vascularity in the capsule had returned to normal.

While it is impossible to state what the final outcome of this plan will be until time has demonstrated late results, it is not too early to state that these results constitute by far the most thrilling experience I have had with this work. The problem of infection of the intestinal wound which has been the bane of all other plans seems to be entirely solved by this plan. It would seem that the infection which naturally follows the suture through the intestinal mucosa is entirely surrounded and made local by normal protective forces before it involves the remainder of the wound. If the late results of this plan prove to be in accordance with the early results, it will take a very important place in this discussion. In the first place, it will completely supplant Plan A in all cases. It must be remembered, however, that this plan, as with Plan A, cannot be used in transplanting both ureters at the same time. All three dogs on whom the bilateral transplantations were used by this technic died within forty-eight hours, notwithstanding that in one of the cases the urine appeared in the rectum in twenty-four hours. Therefore, this plan cannot be safely used in the operation of cystectomy which is to be performed in one stage. It cannot be used safely even in a two-stage operation if one ureter is dilated and the kidney correspondingly damaged, lest the damaged kidney might fail to function while the normal kidney is laid up for repairs. Plan C might conceivably be used as the one of choice if both ureters and both kidneys were entirely normal. Such a plan as the following might be practical: At the first operation, let us say, we transplant the right ureter. After the urine is being delivered freely into the intestine and the kidney has apparently recovered, make a low incision through the left rectus, transplant the left ureter by the transfixion technic, (which operation requires at most only fifteen minutes for its performance and does not open the bowel) and while this wound is open, remove the bladder according to the technic which has been described. This plan is not recommended until further experimental work has been done.

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TEN YEARS OF THE TUNNEL SKIN GRAFT*

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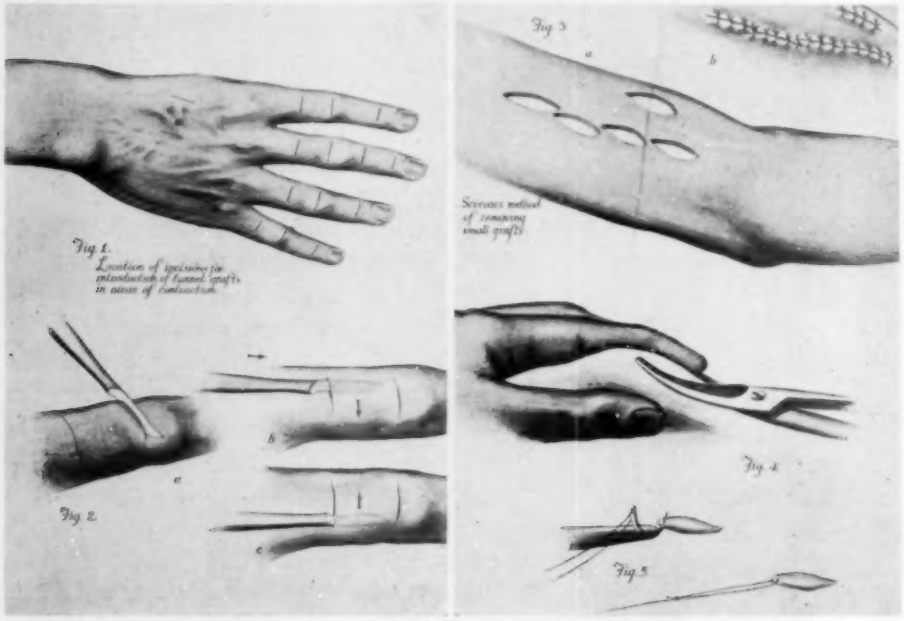
The tunnel method of skin grafting has been in use for the past ten years on the Surgical Service of the Walter Reed General Hospital. It was first described in 1922 [1] by my assistant, the late Major A. D. Parce, Medical Corps. During the succeeding years there has been ample opportunity to study the terminal results and, based on these results, the field of usefulness



of this type of skin graft has been materially extended and the technic simplified.

The first patient on whom this method was employed was a soldier, a veteran of Chateau Thierry, who had several healed scars on the anterior surface of his leg and a large posterior scar measuring twelve inches long and two inches wide. This extended from above the popliteal space downward nearly to the point of insertion of the tendo achillis. The scars resulted from operative incisions for the treatment of osteomyelitis and gas gangrene following a gunshot wound of the leg. The posterior scar prevented complete extension of the leg and seriusly interfered with the blood supply of the tissues. In addition there was a large indolent ulcer more than two inches in its greatest diameter in the centre of the scar harboring staphylo-

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coccus aureus. Numerous attempts had been made to sterilize and heal this ulcer without avail.

To quote Major Parce, who described this case in his article:

> On August 6, 1920, under gas-oxygen anæsthesia, several rectangular grafts were removed from the thigh of the same leg with a safety razor blade, turned inside out over dental composition and sutured. A longitudinal incision was made on either side of the scar, the intervening tissue tunneled beneath and the first graft inserted on the freshly cut area beneath the tunnel. Another tunnel was made below the granulation tissue of the ulcer and a second graft placed therein. . . . The first step was done with a view of lengthening the contracted scar tissue and relieving tension on the ulcerated area, thereby improving its nutrition. The second step was made with the hope that the overlying granulation would hold the graft firmly in place until the epitheliazation could take place beneath, all previous grafts on the unsterile surface of the ulcer had sloughed completely in two or three days. The whole procedure was done with the idea of allowing the rigid scar tissue to stretch further.
>
> On August 14, 1920, nine days after operation, the roof of the tunnel above the dental composition was cut, and the dental composition removed, revealing epitheliazation of the floor without any sloughing of the graft. . . .

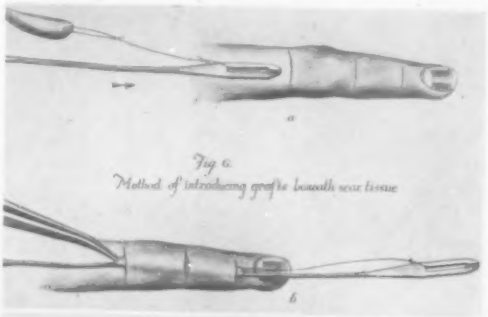


Fig. 6.
Method of introducing grafts beneath scar tissue

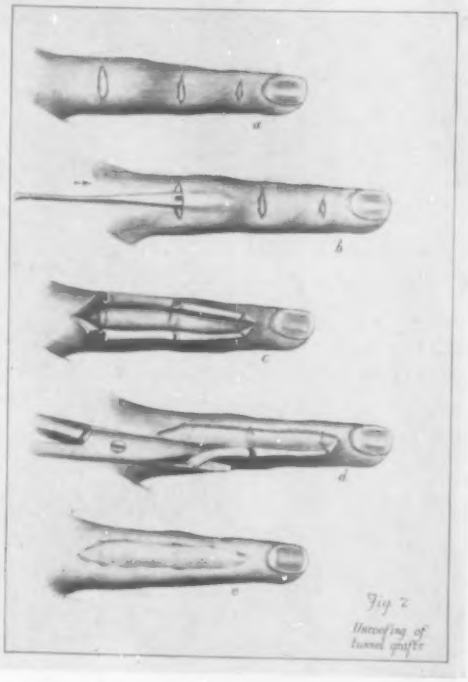


Fig. 7
Unroofing of tunnel grafts

This case was included by Major Parce with other cases, illustrating an improved method of skin grafting based on the principles underlying the Esser inlay graft, but the only thing common to this method and the tunnel skin graft was the fact that the skin to be grafted was "turned inside out over dental composition and sutured." The principle of the tunnel skin graft is entirely different from Esser's, as by the former method the transplanted graft is buried completely within the tunnel and surrounded by tissue above and below, the dental composition being used only as a convenient obturator to aid in insertion and to maintain pressure. The use of the dental compound was later discontinued as being unnecessary.

The tunnel method should not be confused either with the "niche" graft of Alglave, used by him in granulating tissue, and which is actually a modi-

fied Reverdin graft; or the Westhues graft, which is a modification of the Thiersch graft, whereby narrow strips of skin to be grafted are woven in and out through the granulating surface.

The skin used in the tunnel method is a true, thick graft, inasmuch as it contains all layers of skin and is a free mass of tissue wholly deriving its nourishment from the tissue in which it is placed, and because of the fact that in some instances the tunnel graft is tubulated, it should not be confused with tubed or pedicle grafts, which are really not grafts at all.

The tunnel skin graft has been used successfully in nearly every variety

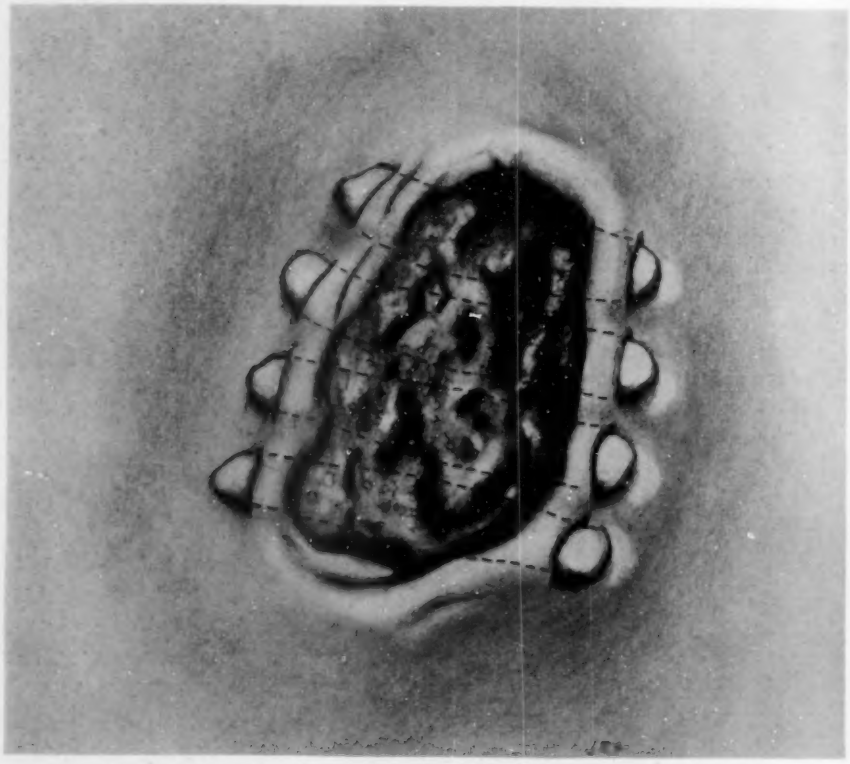


FIG. 8.—Full thickness graft under granulating ulcer tunnel.

of chronic ulcer in practically every location on the body surface. It has been especially useful in case of ulcers located in areas of limited nutrition, as in the centre of old scars. It has also been used to break the continuity in scar tissue contractures following burns in the anterior and posterior axillary folds, on the posterior surface of the thigh and leg and elsewhere. When used in large granulating surfaces following recent burns where scar tissue contraction is to be expected, a graft or a series of grafts, if placed at right angles to the line of expected contraction well under the granulating surface, before any contraction has actually taken place, will break the continuity of the fibrosis and prevent contraction. The change of position of the transplanted graft has had no apparent effect on the take or upon

Scar tissue contraction incident to burn before the application of tunnel graft.

Two years after the application of tunnel graft.

Destructive gasoline burn dorsal skin of fingers.

Appearance of grafts three weeks later.

Tunnel grafts cut out on the sixteenth day.

Full thickness tunnel grafts in position.

Posterior view contractile bands, following gasoline burn.

Lateral view.

Contractile scar eliminated by two tunnel grafts.

the reëstablishment of the circulation. The tunnel graft has in addition been used in anal, annular and rectal strictures, and will be the subject of a future paper if the strictures do not recur after a reasonable period.

The technic now used is much simpler than that used in our earlier cases, but necessarily varies somewhat according to the location of the tunnel or the condition for which the graft is used. The same general rules of skin grafting apply in this method as in the various classical methods. The

Granulating surface ready for full thickness tunnel grafts.

Nine grafts each nearly one-half inch wide when cut, contracted to almost half that width before introduced into the tunnel. Contracted graft permits more stretching during motion.

source of the graft is unimportant except due consideration should be given to the location as to texture, hairlessness and other features according to the position of the graft. The use of the autograft is imperative.

The skin of the area from which the graft is to be taken and the area which is to be grafted are prepared the day before by washing with green soap and water, shaved if necessary, cleaned with ether and alcohol, painted with half-strength tincture of iodine, the iodine removed with alcohol and the part covered with a sterile dressing. When grafts are to be placed under ulcers or granulating tissue the surface should be treated with Dakin's solu-

tion or otherwise for several days, and any deleterious effect of the antiseptics need not be feared when using the tunnel graft.

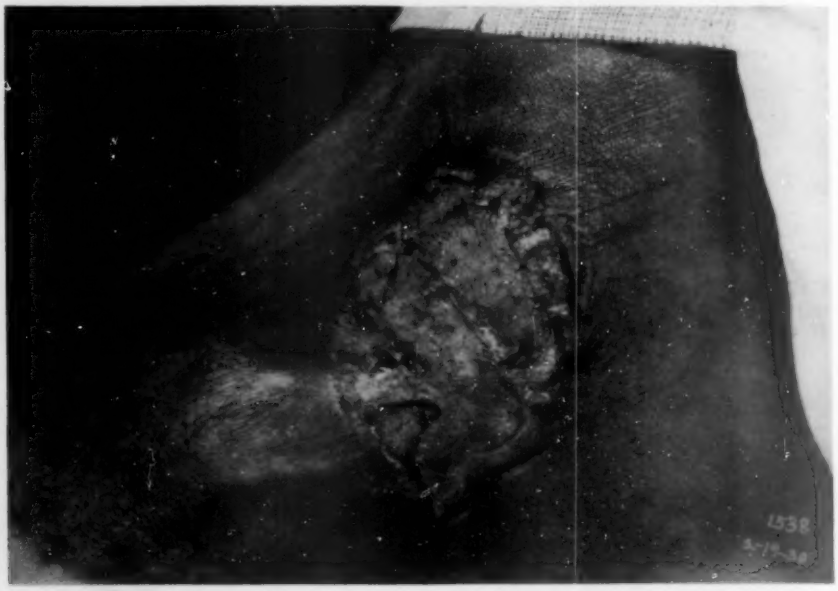
Granulating surface (of ankle) ready for full thickness tunnel graft.

The graft is outlined on the skin, of a size estimated to be necessary, and carefully and gently dissected from the area with a sharp knife, obtain-

Five days after operation, showing partial absorption and tunnel of granulation tissue.

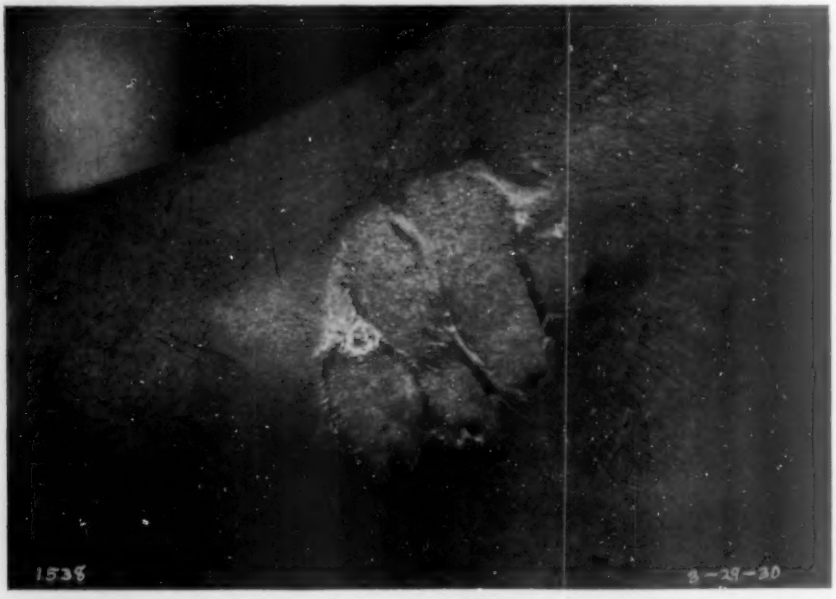
ing a graft as fat free as possible. The smaller grafts may be cut out with a curved scissors and fat removed (Fig. 5). At first the skin to be trans-

planted was sewn over a flat piece of dental compound or over a metallic plate with the skin surface turned inside out before it was introduced into the



Ten days after graft. Almost complete absorption of granulating tunnel.

tunnel, but this has been discarded. Now all grafts are simply placed in the tunnel with the raw surface in contact with the surface to be grafted.



Three weeks after grafting. Skin normal in appearance and wound perfectly healed.

In cases of large contracted bands of scar tissue in the axillary folds or in the thigh where a wide graft is necessary, the use of a large trocar and

cannula simplifies the operation and is accomplished by passing the trocar beneath the scar tissue requiring division and removing the male portion, leaving the female part in place. The full thickness graft, free from fat,

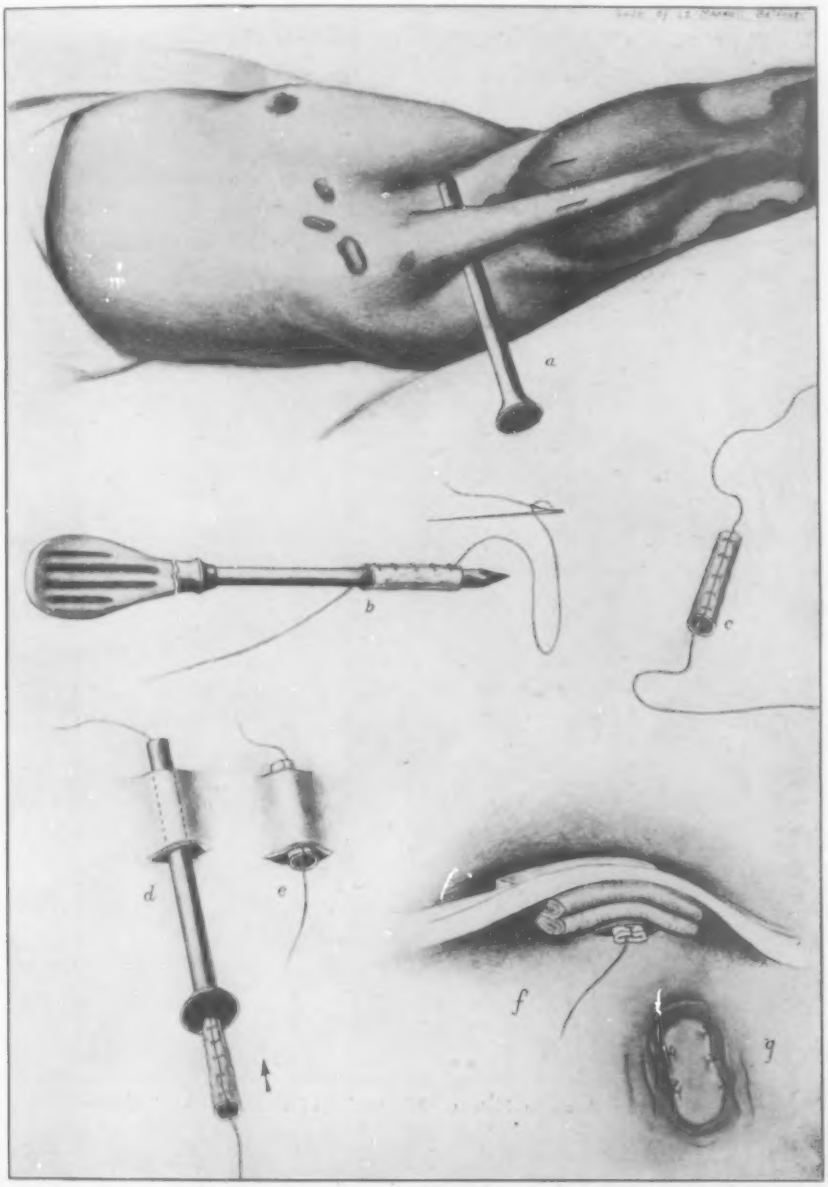


PLATE 1.—Technic of introduction of tubulated graft. "G" represents occasional suture from skin margin to graft after tunnel is removed. (Trocar too small)

is tubulated by sewing it over the male portion of the cannula with the skin surface toward the metal. The sutures are left long at each end for future use in guiding the graft through the cannula while the latter is being

removed (Plate 1). This method of introduction insures less hæmorrhage and more uniform pressure by the surrounding tissues than when the tunnel is made with a cutting instrument as is often necessary when grafting the fingers and other surfaces with little areolar tissue.

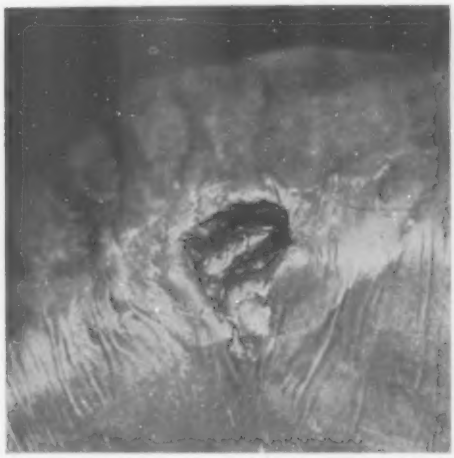
When grafts are used under granulating tissue or under ulcers, the tunnel is made by passing a narrow scalpel between the granulating tissue and the

Result of case shown in Plate 1. Elimination of contractile band of posterior axillary line.

vascular membrane with the flat surface of the knife hugging the membrane. The graft is not tubulated as when used under ulcerated tissue, but is introduced flat, singly, or in a series of separate spaces under the ulcer or granulating surface (Fig. 8). In some cases the granulation tissue may show some discoloration on being separated by the scalpel from the underlying vascular tissue.

The operation completed, the area over the graft is covered with five

layers of gauze impregnated with vaseline, held in place by a tight bandage and the limb or part splinted. The bandage is tightened on the fourth day and the dressing is not removed for two weeks if the tunnel is under scar tissue. When used under granulation tissue or under an ulcer, the dressing may have to be changed earlier and in these cases the bridge of tissue forming the roof of the tunnel may partially disappear by the fifth day, owing to maceration incident to secretion and necessary pressure. Such cases are dressed on the fifth day when the vaseline pad is changed, and are not disturbed again for another five days. On the fifteenth day the roof of the tunnel is divided in the mid-line of a flat graft or over the line of sutures of a tubulated graft. The edges are trimmed or simply allowed to atrophy, the parts are flushed with 10 per cent. argyrol solution and the



Chronic ulcer in the centre of old scar, following burn.

Four weeks after. On the surface above graft will be seen many grafts introduced during the granulating period to prevent scar tissue contraction incident to fibrosis.

vaseline gauze reapplied. If desired, the grafts may be exposed to the air, protected by a wire gauze screen for a week.

The tunnel method of skin grafting seems to offer several advantages compared with the various classical methods. It is most useful in depressions or folds of the body, such as the axilla and other locations where superficial grafts are notoriously difficult to maintain in accurate apposition, and this graft can be applied beneath a granulating surface more successfully than a superficial graft can be used on top. The vitality of the graft seems greater and, if necessary, dressings may be removed whenever desired, even within twenty-four hours, without disturbing the graft. This is particularly useful when the surface is potentially infected as when used beneath a chronic indolent ulcer. With this method, close apposition is assured, movement less likely, accurate cutting and fitting is unnecessary, and the maintenance of proper tension is no problem.

Where Dakin's solution or other antiseptic is used in preparing the

surface to be grafted, the tunnel graft is more likely to take as it seems to be less affected than a surface graft. The whole procedure is quicker and less tedious than the classical methods, the surface to be grafted is more easily prepared, and there is less hæmorrhage, which is sometimes of distinct advantage.

One of the most important uses of this method of skin grafting is in overcoming the contracture of old scars. In these cases the removal of all scar tissue is unnecessary in preparing for the reception of the graft and, being a whole thickness graft, the usual layer of fat is soon developed and adherence to the underlying tissue is unlikely. The graft is freely movable, elastic, and capable of adjusting itself to a movable contour of underlying parts.

This type of graft has been more universally successful in its growth than any other type used by the writer. The reason why such grafts are so successful has not been determined, but their very satisfactory growth might in a measure be due to the fact that the graft once in position is fixed on all sides, so that it cannot be displaced and it is protected from trauma during the early period of its growth. It is completely surrounded by living tissue and, as any graft must subsist on lymph for several days, the plasma circulation is more efficient and completely bathes the transplant within its tunnel, furnishing an ideal environment, as no better medium could possibly be obtained for the preservation of the grafted tissue. It seems probable also that the capillary circulation is more quickly established and the period of defective nutrition shortened or postponed.

REFERENCE

[1] Parce, A. D., M.D., Major, Medical Corps, U. S. A.: An Improved Method of Skin Grafting, ANNALS OF SURGERY, p. 658, June, 1922.

END-RESULTS IN BUNION SURGERY

By Leonard Barnard, M.D.
of Oakland, Calif.

from the orthopedic department of the state university of iowa children's hospital

In the Orthopedic Department of the State University of Iowa on the service of Dr. Arthur Steindler, during the years from 1916 to 1929, there were performed approximately two hundred and forty-six operations for Hallux Valgus. Of this number two hundred and nineteen have been followed for varying periods from a few weeks to ten years, and one hundred and seventy-two have a follow-up of one or more years. From these two groups an attempt will be made to evaluate the various procedures as practiced in this clinic. The cases were all operated upon by house and staff surgeons, the former group being a changing one from year to year. Most of the cases were from clinic groups, but a considerable number were private cases, so that they may be said to represent a fair cross section of an average surgical practice.

Classification.—All bunions fall generally into the groupings of static, arthritic, and paralytic, in that the production of the deformity is associated intimately with one or the other. This neglects only the traumatic which are really very rare and for practical purposes may be omitted.

We will not attempt to enter into the determination of the factors and theories of the static type, but will confine ourselves to the consequences of the surgical therapy.

Symptoms.—The major symptom is pain in practically all cases. Deformation, difficulty in walking, inability to get proper or comfortable shoes, recurrent swelling and abscess formation were among the most common accompanying complaints. The duration of symptoms varied from a few months to years. In the static group the duration of deformity was in several cases from childhood.

About 30 per cent. of the static deformity had a concurrent ankle valgus or metatarsalgia. In the arthritic group the lesion was usually combined with other marked deformities, which was also true of the paralytic.

Surgical procedures.—The most commonly used method of bunionectomy is that known as the Mayo-Hueter operation. This involves resection of the metatarsal head and the swinging in of an adductor flap to produce an arthroplastic effect. Another very much used method is that of Silver, which is essentially the removal of the exostosis and the shortening of the adductor flap in resuturing it. In the Porter procedure the exostosis is chiseled off and a purse-string suture thrown around the adductor orifice to draw this ligament tense.

The oldest method is that of excision of the exostosis. There are many others, such as the Kellar, which involves resection of the phalanx, and the

Ludloff, which osteotomizes the metatarsal shaft to obtain correction. Similarly many modifications involve plastic work upon the soft structures about the joint.

In this series the procedures will be confined to the (1) Mayo-Hueter, (2) Silver, (3) Porter, and (4) Excision of exostosis.

Definition of results.—In this group a *good* result shall be considered as one in which there is absence of pain, free mobility of the joint, and one which is free from deformity.

A *fair* result is that which has absent or only occasional mild pain, moderate limitation of joint motion, small return of deformity, but which is generally a better foot than prior to the operation.

A *poor* result is defined as that which has not improved, has recurred, has persistent pain, or has such limitation of motion of the great toe as to interfere with function.

In all the statistics, unless specified, the operation refers to the individual foot and not to the patients. The percentages are reported in round numbers, no attempt being made to add fractions.

Patients.—The two hundred and nineteen operations were performed on a total of one hundred and thirty-five patients. The average age of the patients was 38.9 years, the youngest being 8, and the oldest 67 years of age. In the group the ratio of females to males was approximately 3:1 (163:56). The operation was bilateral in eighty-seven and unilateral in forty-five cases. The right foot was operated upon one hundred and twelve times and the left, one hundred and seven times.

TABULAR ANALYSIS OF CASES

	Late Group	Entire Group
1. *Type of Bunion*		
(Post-operative observation one year or more)		
Static	108—62 per cent	149—68 per cent
Arthritic	51—29 per cent	53—24 per cent
Paralytic	13— 7 per cent	16— 7 per cent
Traumatic	0 0	1— 0.4 per cent
Total	172 cases	219 cases
2. *Type of Operation*		
Mayo-Hueter	105—61 per cent	134—61 per cent
Silver	37—21 per cent	43—19 per cent
Porter	18—10 per cent	27—12 per cent
Excision	12— 7 per cent	13— 5 per cent
Miscellaneous	0— 0	2— 0.9 per cent
3. *End-Results All Types Combined*		
Good	118—68 per cent	177—80 per cent
Fair	38—22 per cent	29—13 per cent
Poor	16— 8 per cent	13— 6 per cent

		Late Group	Entire Group
4. *End-Results of Individual Procedures*			
A. Mayo-Hueter	Good	74—70 per cent	109—80 per cent
	Fair	21—20 per cent	19—14 per cent
	Poor	10— 9 per cent	9— 5 per cent
B. Silver	Good	28—75 per cent	34—79 per cent
	Fair	4—10 per cent	4— 9 per cent
	Poor	5—13 per cent	5—10 per cent
C. Porter	Good	11—61 per cent	22—81 per cent
	Fair	5—27 per cent	4—14 per cent
	Poor	2—11 per cent	1— 3 per cent
D. Excision	Good	8—66 per cent	10—76 per cent
	Fair	3—25 per cent	2—15 per cent
	Poor	1— 8 per cent	1— 7 per cent
5. *Results by Diagnosis in the Late Group*			
A. Static	Good	77—71 per cent	
	Fair	21—18 per cent	
	Poor	10— 9 per cent	
B. Arthritic	Good	35—68 per cent	
	Fair	11—21 per cent	
	Poor	5— 9 per cent	
C. Paralytic	Good	10—76 per cent	
	Fair	1— 7 per cent	
	Poor	2—15 per cent	

As to the value of the different procedures in the different types of diagnosis, no data are obtainable except as regards the static. In this the results seem equally distributed among the four types of operation and show no type to be outstandingly superior. The paralytic cases were practically all the subject of the Mayo-Hueter method, while the arthritics were confined to the Silver and Mayo-Hueter procedures with about equal results.

It is to be remembered that, in evaluating these statistics, the type of operation was chosen to fit each case and no particular method was on trial.

In analyzing the failures, the principal difficulty in the Mayo-Hueter method was stiffening of the joint with pain. In the other methods the return of deformity was more often the cause of failure.

CONCLUSIONS AND SUMMARY

1. The general distrust in operation for Hallux Valgus is not justified. The low percentage of poor results (less than 10 per cent.) is better than in most surgical procedures and warrants the conclusion that these operations stand on firm ground.

2. Pain is the most constant presenting symptom, and the cosmetic factors are of secondary importance.

3. Two types of end-results are presented, one in which the condition on discharge is considered the basis and the other after a period of at least one year has elapsed. This has served to show that the late results are not as good as the early, and accentuates the importance of using late results as the criteria of procedure.

4. Generally speaking, the results of the Mayo-Hueter and Silver operations have been the most satisfactory over the longer period. However, the small number of cases in some of the groups must be considered before they are condemned.

5. The individual operations show little variation in their value in considering the different types of bunions, *i.e.*, whether static, arthritic, or paralytic.

6. The results in this group were best in paralytic, next in static, and poorest in arthritic. The variation is, however, less than is usually presented.

7. The selection of type of operation should be made to fit the individual case, and we cannot hope for a single procedure to be satisfactory in all cases.

TRANSACTIONS OF THE PHILADELPHIA ACADEMY OF SURGERY AND THE NEW YORK SURGICAL SOCIETY

ANNUAL CONJOINT MEETING HELD FEBRUARY 13, 1930 AT PHILADELPHIA

DR. GEORGE P. MULLER, President of the Philadelphia Academy of Surgery in the Chair

CALVIN M. SMYTH, JR., M.D., RECORDER

COAGULATION OF BLOOD

DR. ISIDOR S. RAVDIN, of Philadelphia, read a paper entitled

THE COMPARATIVE VALUES OF CALCIUM AND GLUCOSE AS AGENTS FOR DECREASING THE CLOTTING TIME OF BLOOD

for which see page 801

DR. FREDERICK W. BANCROFT, of New York City, remarked that at the Fifth Avenue Hospital in New York for the last three years they have been making studies of thrombosis and embolism with the idea of learning something about these conditions.

It was found that the bleeders could be divided into two groups: those definitely hæmophiliac with a low blood platelet count; and others with nutritional bleeding. It was found that the ordinary clotting time did not give a true index of the patient's bleeding reaction. Nutritional bleeders, on a high protein diet, regain their normal factors and become satisfactory operative risks. A number of tonsillectomies were referred for bleeding, and after placing them on a high protein diet, particularly liver, pancreas, brain, etc., it was possible to reduce the clotting time. Another type was the case of uterine bleeding without obvious pathological lesion—patients who had been curetted numerous times and in whom the bleeding still continued. When placed on a high protein diet the uterine bleeding ceased, but when the diet was not followed it started again. As it is extremely difficult to place post-operative patients on a suitable bleeding or clotting diet Doctor Bancroft has been experimenting to determine what drugs might influence this condition. In dogs he has found that the administration of glycocholate will definitely improve the clotting factors and shorten the bleeding time. In a study of patients suffering from thrombosis and embolism (the opposite pole of the bleeding problem) he finds that thrombosis and embolism are rare following operation in parts of the body where there is no active motion. For instance, in skull operations, even though the operation occurs in a vascular area, post-operative pulmonary complications are exceedingly rare. In operations on the abdomen, where post-operatively there is extreme motion due to vomiting and distention and where there is a great deal of subcutaneous fat, thrombosis and embolism are frequent. It occurred to the speaker that the fat might have something to do with the production of

embolism. By injecting an emulsion of fat into dogs, he found a tremendous increase in clotting factors. He has wondered whether emulsion of fat that occurs due to operative trauma may not be a factor in the causation of thrombosis and embolism.

Glucose in the concentrations given for post-operative shock have been the basis of study by Doctor Rosenthal, of Mt. Sinai Hospital. He has not found any change in the bleeding or clotting time following this procedure. In dogs they have carefully tested the clotting factors following intravenous glucose in concentrations of 5 and 10 per cent. without any noticeable change. Doctor Bancroft believes with Doctor Hunt, of the Otolaryngeal Service at the Fifth Avenue Hospital, that the bleeding and clotting time is not a true indication of a patient's bleeding susceptibility.

BONE METASTASIS IN CANCER OF THE BREAST

Dr. John Berton Carnett, of Philadelphia, read a paper with the above title for which we see page 811.

Dr. Burton J. Lee, of New York City, remarked that recently a survey was made, at the Memorial Hospital in New York, of 100 cases of carcinoma of the breast with metastasis to the osseous system. Fourteen of these patients had an involvement of the humerus, upper portion of the sternum or clavicle. Further study of these fourteen cases revealed that but three showed metastasis to one or more of these bones on the same side as the lesion of the breast, while in eleven of the patients the cancer of the breast was on the opposite side to the lesion or lesions in these bones. The lowermost axillary nodes connect with lymphatics down the arm to the vicinity of the nutrient foramen of the humerus so that any invasion of the humerus above this point might be accounted for by lymphatic extension.

Lymphatic permeation to bone from carcinoma of the breast would appear a probable method of extension if the most reasonable line of lymphatic permeation is found in the majority of cases, a finding not in accord with our study of these fourteen cases. Upon the other hand, he recalled a patient with a large mass of metastatic supraclavicular nodes who developed, at the end of two years, a definite extension to the clavicle immediately adjacent to the invaded nodes. In this case one had a clear demonstration of an extension by lymphatic permeation from the nodes directly into bone.

Lymphatic extension to bone in cases of mammary cancer does occur but Doctor Lee does not feel that it will be found with as great regularity as Doctor Carnett's paper would lead one to believe.

Dr. George Semken, of New York City, said that it is highly improbable that the bony metastases that occur in cases of cancer of the breast can be ascribed to permeation via the lymphatic channels, mainly because of the absence of any demonstrable lymphatic connection of this type. It seems more logical to ascribe these metastases to emboli of cancer cells, carried to the bones in the blood-stream. This mechanism was conclusively demonstrated by M. B. Schmidt in his monograph upon the methods of dissemina-

tion of cancer ("Die Verbreitungswege der Karzinome," etc., Jena, 1903), the significant finding in which was the frequent and widespread occurrence of such cancer emboli in the small arteries of the lung parenchyma.

The apparent predilection of cancer metastases for sites within the substance of the bones may be explained by the relative quiescence of those regions. Cancer metastases are rarely found in the skeletal muscles, which are in active motion. It is possible, thus, that Doctor Carnett's observation of a low incidence of cancer metastases below the knees and below the elbows may be explained by the increased range and activity of motion in the legs and feet and in the forearms and hands as against those of the thighs and arms respectively.

Doctor Carnett's finding of an apparent tendency of the metastases from cancers of the breast to invade the neighboring bones—the clavicle, humerus and the ribs—before appearing in the os innominatum, femur and other distant bones, is not in agreement with the speaker's experience. The bone sites most frequently involved in metastasis, that have come under his observation, have been the vertebræ and, next in order, the os innominatum and the upper femur. The vertebræ, in some instances, seemed to be the only bones so attacked.

The subject of cancer emboli, transmitted via the blood-stream has received little consideration, but deserves the greatest emphasis, and should be ever present in the minds of all who palpate the cancerous breast to establish the diagnosis, and who handle the breast and its related tissues during the course of the radical operation. Breast cancer advances not alone along the lymph-spaces into the lymphatic vessels, but it regularly invades the veins also, filling their lumen to a greater or less extent with cancer thrombi. It does not require much force to dislodge these thrombi and to send the cancer emboli into the blood-stream. Many of these cells fail to survive, especially if enclosed in a blood clot, but others remain unenclosed or grow through the clot and the distant metastases are the result. The finding of such cancer thrombi in the cancerous breasts removed by operation is so frequent an occurrence that the pathologist's report of such findings no longer excites any comment—except the doubt that thus arises as to the ultimate prognosis. It has been fairly well understood that the cancerous breast should be examined gently; but too many still disregard this caution in a wholly unnecessary attempt to determine the consistency of the tumor by firm pressure especially between the thumb and fingers. Equally important and probably deserving of greater emphasis, is the need to handle the breast with the greatest gentleness during its removal, even at the expense of technical inconvenience. He was firmly convinced that many metastases have had their start in the injudicious pressure or traction exerted by the surgeon or his assistants during these operations, as well as during the course of the clinical examinations.

Dr. John B. Carnett, in closing the discussion on his paper, said that the last case came to autopsy and the bone showed cancer. It might be a combination of the two, but whether or not Paget's disease was present he

does not know, but he does know that one gets this picture uniformly in metastasis to bone. The speaker was not able in the short time at his disposal to go into the various reasons for believing that this is permeation rather than blood-stream metastasis. In the case of breast cancer one can predict with comparative certainty what it is likely to do. One is sure that it will not show up first below the knee or below the elbow in the great majority of cases. This one case with advanced disease below the knee is unique in Carnett's experience. If one sees destruction of the femur other evidences of permeation are seen in between. In osteomyelitis the blood-borne infection to the tibia is common; if that is true one would expect the same thing in blood-borne emboli. It happens almost never except in this case and one practically never finds disease below the elbow or below the knee, except that centrifugal spread from the shoulder down the length of the humerous and some of the femur before the disease passes over the joint. The reason that it appears in the tibia and radius before the extreme lower end of the femur or humerus is involved is because the cells go over the lymphatics in the soft tissues of the joint more rapidly than down through the bone.

OSTEITIS FIBROSA

Dr. Elridge L. Eliason, of Philadelphia, read a paper with the above title for which see page 833.

Dr. John Douglas, of New York City, remarked that this subject is of particular interest because there is so much confusion as to the various ideas of etiology and pathology. It is known that osteitis fibrosa occurs most frequently in children who are most apt to meet with trauma of various kinds and the lesions are most apt to occur where trauma is most frequent. It is sometimes difficult to link up the history of the trauma with the presence and size of the lesion. A history of severe trauma is sometimes so far back that it has no relation apparently to the lesion present. In other cases, trauma a short time before the appearance of the lesion may not have been the cause of the lesion but simply may have called attention of the patient to the lesion.

Of the three theories as to etiology and pathology which have been enumerated by Doctor Eliason, *viz.*, traumatism, infection, a type of new growth (some form of pathological lesion due to the formation of new tissue), there are evidences which make it difficult to controvert any of these theories, but the weakest is the etiologic factor of infection. It does not act like an infection. Cultures have been made and no organisms found and the curious way in which the lesion spreads after removal or heals after a fracture when nothing else is done does not resemble what one would expect in an infectious process or a neoplastic lesion.

Whether these various lesions are all progressive stages of one condition or whether the lesion starts as a definite pathological entity is hard to explain. In some cases a large number of giant cells are found and in others very few. The essential pathology according to Ewing is replacement of bone marrow

and the inner portion of the cortex by fibrous tissue. It may continue to grow as fibrous tissue; it may develop into a cyst. In some cases the fibrous tissue develops into some type of sarcoma and then a cyst develops in the sarcoma. The lesion spreads rapidly sometimes, and sometimes slowly. The differential diagnosis between benign and malignant conditions, between osteitis fibrosa and other forms of lesion in the bone is difficult. But the peculiar trabeculation of the bone as shown by the X-ray in these cases is characteristic.

DOCTOR DOUGLAS then showed lantern slides illustrating the progress in nine cases of this disease which he has had under his care.

DR. FENWICK BEEKMAN, of New York City, said that he had seen but five cases which he could positively say were osteitis fibrosa cystica. Two of these were seen with Doctor Bancroft, on his service, at the Lincoln Hospital. Only two of the patients were operated upon. In four of the five cases, which came under his observation, the patients did not know they had this condition until they sustained a pathological fracture. The diagnosis is difficult. In July, 1914, Barrie, in *Surgery, Gynecology and Obstetrics*, discussed a condition which he called chronic hæmorrhagic osteomyelitis. His description of this condition was similar to that of the so-called giant-cell sarcoma of bone, the microscopic pictures showing the typical histology of a giant-cell tumor. Doctor Eliason's third case impressed the speaker as one of a hæmorrhagic tumor of the bone. Again, he observed a patient some years ago who had a mass in the lower end of the radius, the röntgenogram showing a picture similar to that of one of the cases presented by Doctor Douglas; this later was proved to be syphilis. Bloodgood believes that most of these lesions of osteitis fibrosa cystica are only discovered following a pathological fracture. He also states that the condition will heal by itself, the child growing out of it. In the first case mentioned by Doctor Beekman, he curetted the bony cavity to remove the membrane and followed this with cauterization by carbolic acid. This patient was followed for one and a half years and the condition of the child showed improvement. The second individual had an involvement of the upper end of the femur; the cavity was curetted and a flap of muscle turned into it. During the period in which this patient was observed, one and a half to two years following operation, the condition improved materially, new bone being formed within the cavity. In the three other patients, no operative procedure was undertaken—one of them was lost track of and the other two showed decided improvement over a period of two and a half years.

TRAUMATIC RUPTURE OF THE DIAPHRAGM

DR. HENRY P. BROWN, JR., of Philadelphia, presented a colored boy of nineteen years who was admitted to the Presbyterian Hospital after having been injured a short time previously in a motor accident in which he was thrown violently against the steering wheel of his truck. On admission he showed localized tenderness and some rigidity over the upper left quadrant of his abdomen and lower aspect of the left side of his chest. Examination revealed localized tenderness in the above area within

twenty-four hours. Physical signs of a left pneumothorax developed and an X-ray picture apparently confirmed the diagnosis. He progressed satisfactorily until about to be discharged two weeks later when another X-ray suggested herniation of the diaphragm, which was confirmed by gastro-intestinal X-ray.

On operation, the approach to the hernia being through the abdomen, it was found that there was a tear on the left side approximately eight centimetres in diameter extending laterally from the œsophagus. The fundus of the stomach, most of the transverse colon with the omentum, and some of the small intestine were found to be within the chest. Adhesions were present around the edges of the opening in the diaphragm, showing that the condition was of recent origin and not congenital in character. By grasping the edges of the opening with hæmostats, the negative pressure in the chest was overcome and the herniated viscera were reduced within the abdomen. The opening in the diaphragm was closed with interrupted sutures of chromic catgut, reinforced by a continuous layer of the same material. The abdomen was closed without difficulty.

The patient made a normal convalescence and gastro-intestinal studies made two months later revealed that there was no evidence of hernia. An X-ray picture taken eighteen hours after operation showed that the heart, which had been displaced to the right, had resumed its normal position, and there was no evidence of pneumothorax.

Dr. Howard Lilienthal, of New York City, remarked that there are different kinds of so-called hernia of the diaphragm: 1, a congenital absence of the diaphragm (not a hernia in the strict sense); 2, true hernia with peritoneal covering, whether traumatic or not; and 3, traumatic hernia with rupture of the diaphragm and no peritoneal sac. This last is the type which Doctor Brown presented and in which he got such a splendid result.

The speaker feels very humble and can forgive anyone who mistakes a thoracic stomach for a pneumothorax. He has even gone further and has put a needle into such a stomach, thinking it was a pneumothorax. Fortunately, he did not aspirate anything but air. It was a traumatic case. The patient had "indigestion." He was given a test meal and found the same condition as shown here. At operation it was found that he had broken several ribs, one of which had perforated the diaphragm and produced the hernia. Doctor Lilienthal went in between the ribs and was able in spite of the adhesions present to reduce the hernia and even to sew up the hole in the diaphragm except for an area about the size of half a dollar. The assistant at the operation, Doctor Neuhof, suggested that he take a piece of fascia lata and transplant it, which was done with a perfect result. After several cases of hernia of the diaphragm, the speaker is a firm believer in the transthoracic approach rather than the transperitoneal, for a number of reasons. First, the exposure of the parts is perfect and if any adhesions are present one can find them and do away with them. If the hernia is drawn upon from below and there are adhesions in the chest, one must stop the operation or go in from above anyway. One can deal much better with the hole in the diaphragm when it is in plain sight. Another reason is that there is easy access to the phrenic nerve where it passes across the pericardium; by giving it a pinch, the diaphragm will remain still while you are working on it. Even if permanent paralysis of the diaphragm occurs, the

patient is better off than with a diaphragmatic hernia. Lastly, it is necessary to know that one is not dealing with congenital absence of the diaphragm. He saw one case in which Doctor Lewald, the röntgenologist, was able to diagnose the absence of the diaphragm. The patient, by the way, was a runner.

As to age for operation, Ralph Boerne Bettman, of Chicago, reported a case operated upon by him at the age of three and one-half months for strangulation. He approached through the thorax and did a fine operation, reducing the hernia before he found that he was not able to close the hole in the diaphragm. He cut two ribs and then did not have the slightest trouble in sewing up the diaphragm. This shows how a resourceful surgeon can get around what looks like an insuperable condition.

The speaker thinks that diaphragmatic hernia is much more common than is usually thought to be the case. When a child's digestive system is decidedly disturbed, we owe it to the patient to give it the same chance we would an adult, and to make an X-ray study of the chest, with contrast meal if necessary.

As to the age for operation, what he would prefer to do and what the attending physician would let him do are two different matters. The operative procedure is looked upon by most physicians as a very dangerous one; although it is not nearly so dangerous as to wait until strangulation complicates the case. In the *British Medical Journal* there appeared an article by a Russian surgeon who believes that prolapse of the intestine through the hiatus œsophagis is much more common than we believe, and thinks some of the herniæ in children begin in that way. If there are no symptoms, it might alter his opinion as to when to operate, but usually there are symptoms, and the X-ray examination discovers the presence of the hernia, in which case he thinks it is better to operate early and avoid the dangers of acute strangulation.

FRACTURES OF THE MANDIBLE

Drs. Robert H. Ivy and (by invitation) Lawrence Curtis, of Philadelphia, presented cases of fracture of the lower jaw undergoing treatment. Doctor Ivy remarked that in the average textbook on surgery, under fractures of the mandible, considerable space is given to obsolete methods and little to practical modern treatment. Various types of more or less complicated splints are shown, without specific instructions as to their use, except that they can be made by a dentist. But definite practical information as to how to reduce and fix the fragments quickly and efficiently is usually lacking. Surgeons are being confronted with an increasing number of these injuries owing to a combination of rapid transportation and prohibition, and those skilled in making special appliances are seldom immediately available. Hence, it has been their endeavor to foster the employment of simple methods which can be applied readily in the majority of cases by any surgeon willing to give a little thought to the subject. These methods are not original with them, but are adaptations and modifications of those first introduced by Gilmer. He

did not deny that many cases without displacement will do well with a bandage alone, but these would do just as well without a bandage at all. But no head bandage can be put on sufficiently tightly to fix fragments which show a tendency to displacement, without strangling the patient. Instead of a

FIG. 1.

FIG. 2.

FIG. 1.—Radiograph showing ascending ramus and condyle dislocated forward and rotated at right angles. (Case I.)

FIG. 2.—Radiograph showing replacement of condyle and ascending ramus in normal position. (Case I.)

detailed description of the technic, which is to be found in previous publications, they presented three cases, now actually undergoing treatment:

CASE I.—A man, aged twenty-eight, in an automobile accident November 15, 1929, was struck on the left side of the head by the fender of a car. At the Lankenau

Hospital a deep wound was found beginning behind the left ear, and passing downward over the ascending ramus of the mandible to the neck. The parotid gland and facial nerve branches were severed, and there was a fracture of the mandible at the angle, the ascending ramus and the condyle being dislocated forward and turned at right angles so that the posterior border faced toward the left (Fig. 1). First-aid treatment by Dr. Montgomery Deaver consisted in arrest of hæmorrhage, suture of the ear, and fixation of the lower teeth to the upper by means of brass wires to control the main fragment of the lower jaw. By November 30 the patient had recovered sufficiently to be transferred to the clinic for further treatment. The exposed bone of the ascending ramus had become almost entirely covered by granulation tissue, and practically no suppuration was present. There was almost complete left-sided facial paralysis. The main fragment of the mandible was in fairly good position. The wires on the teeth having worked somewhat loose, it was thought advisable to obtain firmer fixation by applying heavy half-round German silver arches to upper and lower teeth, and in

FIG. 3.—Normal opening of mouth, after treatment. (Case I.)

FIG. 4.—Satisfactory occlusion of teeth after treatment. (Case I.)

turn connecting these with finer brass tie-wires. On December 12, at the Graduate Hospital, under ether, the external wound was enlarged, exposing the outer aspect of the displaced ramus and condyle fragment, care being taken not to completely sever the bone from all soft tissue connections. This fragment was then manipulated into correct position, the condyle being brought back to the glenoid fossa. The lower end was brought in contact with the main part of the mandible at the angle, but no attempt at direct fixation was made (Fig. 2). The attachment of the bone fragment to the soft tissues was so precarious that there was little hope of saving it. Healing over the exposed portion of the bone gradually took place with the exception of a small sequestrum near the angle, and on January 29, 1930, the external wound was almost closed. On this date, the connecting wires between the upper and lower teeth were cut and almost complete union between the fragments had taken place. There was good motion at the joint, the mouth opening being at least two-thirds normal (Fig. 3), and the occlusion of upper and lower teeth was satisfactory (Fig. 4). They believe there has been some improvement in the facial paralysis. They expect later to smooth out the depression left in the healing of the wound, and possibly raise the left side of the face by fascia lata strips.

CASE II.—A man, aged forty years, was referred by the University Hospital January 25, 1930, with history of being struck with a blackjack on left side of face four days before. Examination showed nearly all lower teeth to be present, but several upper teeth on left side missing. The lower teeth on the right side up to the mid-line came into good occlusion with the upper ones, but on the left side there was a downward displacement, so that the cutting edge of the left central incisor was at the level of the neck of the right central incisor. Attempts at closure of the teeth showed independent mobility of the two halves of the mandible. X-ray examination revealed a fracture through the symphysis with an angular turn toward the right before reaching the lower border. There was also a vertical fracture from the sigmoid notch down to the angle on the left side, with little or no displacement. Owing to absence of many teeth from the left upper jaw, the ordinary eyelet method of wiring was not suitable,

FIG. 5.—Gradual reduction of depressed left fragment by elastic bands. (Case II.)

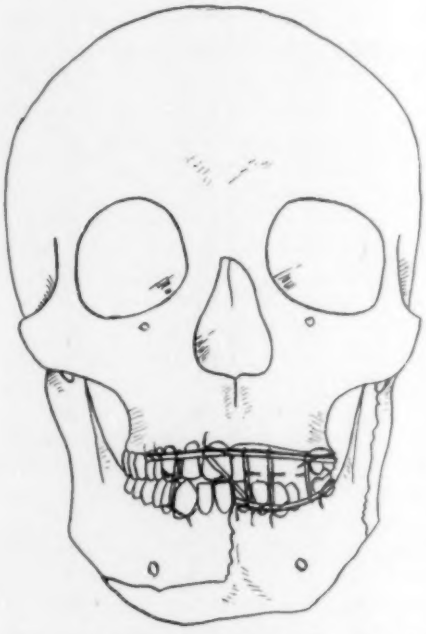


FIG. 6.—Fixation by brass ligature wires after reduction. (Case II.)

so that the somewhat more difficult half-round arch method was used. The case was further complicated by the fact that manipulation would not bring about immediate reduction of the downward displaced left fragment, probably owing to the angular direction of the fracture line. This necessitated gradual traction by means of small elastic bands connecting the upper and lower arches (Fig. 5). At the end of one week, the depressed fragment had been drawn up so that all lower teeth were in good occlusion, and the elastics were replaced by wires (Fig. 6). This gradual reduction by elastic traction is particularly useful in unreduced fractures several weeks old.

CASE III.—A man, aged twenty-nine years, sustained a blow upon his jaw three weeks before admission to the Episcopal Hospital—January 22, 1930. Had received no treatment except a head bandage, and was suffering from insomnia and lack of nourishment. A fracture was found in the right premolar region of the mandible, with marked overlapping of the fragments, the posterior fragment being displaced inward. Considerable suppuration was present. The premolar teeth near the line of fracture had to be removed, and a small incision through the skin made for drainage. Many

teeth were absent, so that fixation was obtained by application of half-round arches to upper and lower teeth. External drainage wound has now healed, and union is progressing satisfactorily, with fragments in good position.

DR. J. J. MOORHEAD, of New York City, remarked that the wiring method as modified by Ivy is simple and effective and much more reliable than the complicated splints such as those of Matas and others. After the immobilization has been done the problem is not complete because every fracture of the lower jaw is essentially a compound fracture and to that end and to that degree osteomyelitis enters into it. The speaker agreed with Doctor Ivy that immediate reduction means easy reduction and that immediate immobilization, properly done by the wiring method, lessens the disability period and is likely to lessen the possibilities of osteomyelitis.

PANCREATIC CYST

DR. JOHN H. JOPSON, of Philadelphia, reported a case of pancreatic cyst associated with calculous cholecystitis. V. C., sixty-four, white male, was admitted to the Presbyterian Hospital, June 3, 1929. For several years he had been subject to mild intermittent attacks of upper abdominal pain, transitory in nature, and without relation to meals. Two years ago he had an attack of very severe pain, located in the left epigastric region, coming on an hour after eating, not associated with vomiting, which lasted twenty-four hours and required morphia for relief. Four weeks ago he had a second severe attack, followed by vomiting, and lasting longer. He was in bed for three days, and since then he has had almost constant pain in the same region. The bowels, formerly regular, have been extremely constipated. He has lost fifteen pounds in weight. Has no history of jaundice or clay-colored stools. X-rays made elsewhere before admission, and a diagnosis of gastric ulcer and ptosis of stomach and transverse colon reported.

Patient's family and previous medical history were good. He had pneumonia once and operations for carbuncle, and drainage of maxillary antrum. His habits were correct. There was no history of trauma. He was somewhat anæmic and showed signs of recent loss of weight. He was not jaundiced. His physical examination, apart from the abdomen, was practically negative. The abdomen was scaphoid. There was tenderness on deep palpation over the middle and left epigastric regions. No tumor was detected. The liver and spleen were not enlarged. The blood count showed a mild secondary anæmia. The Wassermann and Kahn tests were negative. The blood sugar was 80 and the blood urea nitrogen 13.5. Stool examination negative for occult blood. The gastric analysis gave a maximum free hydrochloric acid of 58, and total acidity of 84. The urine was normal. The blood-pressure was 146/78.

Operation June 11, 1929.—Upper rectus incision. No free peritoneal fluid. Liver had rather unusual bluish discoloration on anterior surface. No nodules in it. The gall-bladder was normal in size, somewhat thickened, and filled with small calculi. The common duct was free of stones. Walls of the stomach and duodenum were normal. Behind the stomach, near the mid-line, and situated retroperitoneally was a fixed mass about eight centimeters in diameter, which on palpation was apparently cystic. It was rather difficult at first to establish a line of demarcation between stomach and tumor. A diagnosis was made of cyst of the pancreas. The gall-bladder was first removed in the usual manner. The anterior wall of the cyst was approached through the lesser omentum, after protecting the abdominal cavity by gauze packs. The cyst was aspirated and about four ounces of thin creamy fluid obtained. The inner lining of the cyst was smooth, white and glistening. The cyst cavity was drained externally by a rubber tube, a cigarette drain was placed in the gall-bladder fossa, and a gauze pack used to protect the peritoneal cavity, and control oozing from the lesser omentum.

Convalescence was smooth. The drainage from the cyst cavity was at first profuse, and straw colored. The gauze packing was not entirely removed until June 22. Following this, cyst drained in lessening amounts, and the tube was first shortened, and finally removed twenty-six days after operation. He was discharged July 12 to the care of his physician. The sinus was small. It drained in scanty and lessening amounts for about a month, and then closed. The laboratory reported the fluid as follows: color bloody, odor foul, reaction alkaline, cell count red blood cells 73,600, white blood cells 600, filtres red, albumen a trace, sugar negative, amylose +4. (Only one ferment tested.) Many thick bacilli seen on smear, gram negative organisms, and a few short chain streptococci. (It seems probable that the specimen underwent subsequent contamination.) Patient reports by letter, February 7, 1930, as enjoying exceptionally good health.

DOCTOR JOPSON added that cysts of the pancreas fall into one of a number of types. He would classify this case as a retention cyst for the following reasons: Its apparent location within the body of the gland; the smooth lining, distinguishing it from proliferation, hydatid or dermoid cysts; the nature of its contents, physical and chemical; the association of cholecystitis, possibly a causative agent by production of chronic pancreatitis, which seems to be considered by most authorities as a factor in one way or another in the development of retention cysts. Disease of the gall-bladder, with or without stones, was present in 41 per cent. of cases in Judd's series, although gallstones were present but once in nineteen cases reported by McWhorter. The above statistics are from Speese's recent article in Nelson's "Surgery." Characteristic symptoms were present. The nature and location of the pain, the associated indigestion and constipation, slow growth, and loss of flesh are quite typical. Jaundice, often a symptom, was absent, as were glycosuria and diabetes, the latter results of associated pancreatitis rather than of cyst itself. Tumor, for some reason, was not detected by any of the examining physicians. The high location of the cyst, in the less usual position above the stomach, was perhaps the reason. It is more usual to have it press forward between the stomach and the transverse colon, as Körte pointed out long ago. The operation of drainage in cysts of the body of the pancreas, with or without removal of the lining membrane, is attended with a low mortality. In this case there was no opportunity to attach it to the abdominal wall and the drainage tract had to be protected by gauze packing. The ability to practise cholecystectomy was fortunate, as Speese points out that cholecystostomy may postpone recurrence and cholecystectomy prevent it.

HOUR-GLASS STOMACH

DR. JOHN H. JOPSON presented a woman, aged fifty-four years, who was first seen and first operated upon in 1926 when she was fifty-two years of age. She then gave a history of indigestion extending over many years, in fact, since childhood. After the birth of her first child, twenty-five years before, the symptoms had been very much exaggerated. Her principal complaint was pain in the epigastrium, coming on an hour after eating, and relieved by induced vomiting. The pain was never referred except on one occasion, twelve years ago, when she had hæmorrhages, probably gastric, accompanied by pain in the right shoulder, when she was confined to bed for two weeks. For years she had been very thin, and at the time of her first admission weighed

only ninety-one pounds. The X-ray showed an extreme degree of hour-glass contraction of the stomach, with a large proximal and distal pouch. The first operation was at the Presbyterian Hospital July 19, 1926. Two distinct pathological conditions were found present. There was a marked hour-glass contraction of the stomach, the median portion being stenosed and forming a narrow tube three inches in length, firmly adherent to the under surface of the liver. It apparently represented the site of an old healed ulcer. A more unusual finding was an internal hernia of the small bowel, no evidence of which was present in the X-ray taken before operation, the greater portion of the jejunum and ileum being herniated through a large congenital opening in the transverse mesocolon and another in the right portion of the lesser omentum. The loops of gut lay above the distal pouch of the stomach and between it and the liver. The distal portion of the stomach and the transverse colon were displaced downward toward the pelvis. The opening in the transverse mesocolon was three inches in diameter and just to the right of the ligament of Treitz. The bowel was not adherent and was reduced without difficulty and restored to its normal position below the colon. These openings in the mesocolon and lesser omentum were repaired by suture. The hour-glass contraction of the stomach was treated by gastrogastrostomy, a three-inch opening being made in either pouch. No attempt was made to free the adherent portion of the stomach from its attachment to the liver. The convalescence from this operation was smooth. The patient was relieved from all of her symptoms for two years, and gained considerable weight. At the end of that time she began to suffer with dull pain and swelling in the left lower abdomen. This pain had no relation to eating. She again lost weight, and was readmitted to the Presbyterian Hospital in January, 1929. Physical examination showed a marked degree of emaciation and asthenia, and slight tenderness and some distention in the lower abdomen, left side; otherwise negative. Gastric analysis was normal except for a sub-acidity. The X-ray report was that the gastrogastrostomy opening was very narrow and there was fluoroscopic evidence of pyloric stenosis.

Operation February 6, 1929.—There were extensive adhesions around the site of the previous operation. The pylorus was narrow, but there was no evidence of ulceration at that point. After dissection of the adhesions and mobilization of the stomach, an examination of the gastrogastrostomy opening showed it to be somewhat contracted. The recurrence of obstruction at this point was in part due to this narrowing and in part to perigastric adhesions around it. Three operations were considered, namely, partial gastrectomy, sleeve resection, and double gastrojejunostomy. The last operation was decided upon. There was some trouble in obtaining good exposure of the posterior surface of the stomach, but beyond this there was no particular difficulty. The convelascence was uncomplicated. The patient gained weight after discharge, went back to housework, and when examined in September, 1929, had few complaints except some symptoms of eyestrain, in the way of headache, which were relieved by refraction. Since then she reports herself in good health and is now employed steadily at housework.

The most interesting feature to the reporter in this case was the association of openings, probably congenital, in the transverse mesocolon and the lesser omentum, which permitted herniation of the small intestine into the subhepatic region by way of these openings and through the lesser peritoneal cavity. The drag on the pylorus and distal portion of the stomach, which probably resulted from this herniation, may well have had something to do with the development of perigastric adhesions or ulcer in the pars media which were followed by the hour-glass constriction. He had seen one case of pyloric ulcer in association with diaphragmatic hernia in which practically all of the small bowel had herniated into the left pleura. Other cases of this

character have been reported in literature. The case under consideration had suffered almost from childhood from digestive symptoms. This may have been due to persistent or recurrent herniation of this type. The openings were large, and presumably for this reason strangulation had never occurred.

The methods adopted for relief of hour-glass stomach are numerous. At the present time it is probable that the operation of partial gastrectomy, now so popular, has superseded the other procedures in the majority of cases.

Moynihan, whose experience in the treatment of hour-glass stomach embraces over 100 cases, states that it is gradually displacing other methods in his practise, especially when the ulcer is unhealed or is within an accessible area. However, the speaker had always been intrigued by the double gastro-enterostomy operation since Doctor Gibson presented his paper on this subject in 1923. While the operation has not been a popular one, as Gibson pointed out at that time, and while it is probably seldom performed at present, and he had had no other occasion to use it himself, it is interesting to note that both Gibson and Moynihan had excellent results in the cases in which they found justification for its performance.

Dr. Charles L. Gibson, of New York City, said that every hour-glass stomach is a problem and usually an individual problem. It is hard to decide what is to be done in each particular case. In addition to the size of the pouch there are very dense adhesions, and possibly, volvulus. He showed a print of an X-ray of a trifid stomach where the diagnosis was missed both in X-ray prior to operation and at operation and a gastro-enterostomy was done for what he believed to be the upper and larger pouch and it failed to reveal the condition of the patient. He has operated on two gratifying cases in whom from long-standing symptoms there was emaciation and great detriment to the health. These cases seemed to be particularly well chosen for this operation who have huge stomachs with pouches of about even size and with a very tight constriction. In both cases the operation was satisfactory. Both were followed for five years, at which time they had regained their health and had gained from 25 to 40 pounds in weight, and could eat everything.

In a third case several years ago he did the operation for long-standing symptoms. There were present two great big pouches. The patient died at the end of seven days. Post-mortem showed the condition to be quite irreparable. Doctor Gibson does not think that double gastro-enterostomy in all cases is the best procedure. The large stomachs with the two large pouches of equal size are the best suited. Then, too, in cases where there is a very small cardiac pouch, high up, the procedure is about all one can do. One must remember that in some cases after the meal gets through from one pouch, it meets with another stricture due to cicatrization of an ulcer at the pylorus.

Dr. Carl Eggers, of New York City, discussing the case of pancreatic cyst, remarked upon the close association between affections of the biliary system and pancreatic disease. Exactly what the relationship is, is not easy

to determine. A temporary block in the lower end of the common duct by a stone or congestion may allow bile to flow into the pancreatic duct, and thus start the trouble. Doctors Mann and Giordano, of the Mayo Clinic, have shown experimentally that only in a very few instances is that probable, because the ducts are more likely to empty separately rather than by a common opening into the duodenum. In a certain percentage, however, there is a common end and it would seem feasible that a block at the papilla of Vater might cause the bile to flow into the pancreatic duct.

Clinically it is a fact that in nearly every case of pancreatic disease one finds associated gall-bladder disease. He had had the good fortune to have a number of cases under his care and in a great majority gall-stones were present and in others cholecystitis was present. In order to exclude infection as a factor in these he had cultures taken of the peritoneal fluid, retroperitoneal fluid, and, where he operated on the gall-bladder, of the gall-bladded, and in every case they were negative for all the different organisms. This seems to show that infection as such plays little or no rôle, in the production of pancreatic disease but rather that it is due to chemical reactions. The onset is sudden and acute and this also speaks against the theory of infection. If a gall-bladder inflammation were present and the cause of the pancreatitis the patient would have a few days of illness preceding the onset of his pancreatic disease.

As to Doctor Jopson's case of pancreatic cyst and calculous cholecystitis, he had seen a few such cases and believed that these cysts are secondary cysts or pseudocysts which develop as a late stage of acute pancreatitis. He had operated upon three patients of this type, one of whom he had followed from the very beginning. He saw her early for an abdominal condition supposed to be either an acute appendicitis or gastric perforation. He made a diagnosis of most likely acute hæmorrhage pancreatitis and advised admission to the hospital. This was refused by the patient and she was treated conservatively for several weeks when a mass developed in the epigastrium which required admission to the hospital. At this time the clinical picture had entirely changed. There was a large mass in the epigastrium. Operation disclosed a large pancreatic cyst behind the stomach. Turbid fluid was removed and floating in it was a necrotic portion of the pancreas. All cultures were negative. The gall-bladder was full of stones but was not disturbed at this time, but it was removed at a later date. It seems that these pancreatic cysts like the one Doctor Jopson has shown are conditions secondary to acute disease in which there is death of a certain amount of the pancreatic tissue. If the head of the pancreas is involved the patient dies. If the tail end is involved it becomes separated as a slough and usually flows out with the drainage of the cyst.

Most of the treatment of pancreatic disease should be preventive by treating the associated gall-bladder disease. This is another argument in favor of operating on patients with gall-stones rather than allowing the condi-

tion to go on. Acute pancreatitis has a high mortality unless operated on early.

Dr. John E. Jennings, of New York City, remarked that there seems to be a question in Doctor Jopson's first case as to whether the cyst was coincidental or the result of previous pancreatic disease. He had had the same experience as Doctor Eggers following localized pancreatitis. On palpating the pancreas in the course of gall-bladder or gall-duct surgery one sometimes finds indurated localized masses in the pancreas although a diffuse process is the rule. In three different cases of acute hæmorrhagic pancreatitis he found localized hæmorrhages of the pancreas, which did not involve the head. In one case after incision and drainage, a large portion of the pancreas separated, leaving a cyst cavity which took two weeks to heal. The speaker agreed with Doctor Eggers as to the probability of the origin of these cysts. As to his remarks on the cultures taken for the discovery of infection, he asked whether in these studies anaërobic cultures were made. In a few cases in which he had been able to study hæmorragic and local septic processes, he was able to find anaërobic bacteria and perhaps an analysis of this situation would help to a better understanding of the more acute inflammations and infections of the pancreas which are so violent, so fatal.

SPASMODIC TORTICOLLIS

Dr. Charles H. Frazier read a paper entitled "Interruption of the Afferent System Alone in the Treatment of Spasmodic Torticollis," for which see page 848.

Dr. Byron Stookey, of New York, remarked that the greatest advance in modern times in the treatment of torticollis was presented by Doctor Keen in 1890 in Philadelphia, and it is a great pleasure to hear this subject treated in so masterful a manner by Doctor Frazier forty years later.

Torticollis is an extremely ancient disease judging by the deformity of the skulls which have been removed from some of the ancient Egyptian tombs. The lesion producing torticollis may occur at a number of neural levels in the integration of nerve impulses controlling neck movements. Torticollis may be found in lesions of the spinal accessory nerve and in aneurism pressing upon the spinal accessory nerve. Lesions of the cervical cord cause torticollis and may be referred to as spinal reflex torticollis. Lesions of the more ancient motor system, namely the paleokinetic system, especially globus pallidus and the striatum, may cause torticollis as well as lesions of the more recent motor system, namely the motor cortex and pyramidal pathway.

Apart from disturbances of the neural mechanism at these different levels, local processes may produce torticollis. The most noteworthy of these are found in the congenital form thought to be due to faulty position of the fœtus *in utero* with damage to the blood supply of the sternocleidomastoid muscle and subsequent scar tissue formation. It has been a disputed point as to whether this could be attributed to faulty position or to injury at the

time of birth. However, in one or two instances the position of the fœtus has lead to the diagnosis of wry-neck before the child's birth and in another instance torticollis was found to be present in a child delivered by Cæsarian section which of course rules out the possibility of injury to the sternocleidomastoid muscle by birth. Thus it is fair to infer that congenital wry-neck may be due to the position of the fœtus in utero. It is also possible that injury to the sternocleidomastoid muscle may take place at birth and that subsequent scar contraction may produce rotation of the head and limitation of head movements. Many other local causes may be cited producing torticollis, especially those involving bony changes of the cervical vertebræ and local inflammatory conditions of the vertebræ and muscles.

In considering torticollis we are thus confronted with two major groups, those produced by local changes of the muscles or vertebræ and those brought about by a lesion of the neural mechanism. The surgical treatment of torticollis likewise can be divided into two main procedures, those designed to treat the local effects by local tenotomy or myotomy and those intended to interrupt the neural impulses in either its afferent or efferent arc or both. Tenotomy and myotomy are successful in so far as they treat those forms of wry-neck due to local lesions but are totally inadequate for those forms in which the neural mechanism is implicated.

Isaac Minnius, 1641, is credited with having performed the first open section of the tendon of the sternocleidomastoid and Bujalski, 1835, with having first sectioned the spinal accessory nerve though this is usually credited to Campbell de Morgan, 1866.

Operations designed to interrupt the neural impulses were at first limited to section of the spinal accessory nerves, but realizing that this was an inadequate procedure, since the innervation of other neck muscles was involved, Keen, 1890, at the suggestion of Weir Mitchell, sectioned the dorsal branches of the first three cervical nerves after identifying them among the neck muscles. This operation thus cut off both the afferent and efferent supply of the neck muscles since peripheral nerves were sectioned. Thus Keen's operation may be referred to as peripheral section of the innervation of the neck muscles in which both afferent and efferent impulses were destroyed.

In so far as the speaker was aware, the first published report of an attempt to reach the afferent innervation of the neck muscles by hemilaminectomy and intradural section of the dorsal roots of the first four cervical nerves for the treatment of torticollis was made by Alfred S. Taylor, of New York, in 1910, and published in Johnson's "Operative Therapeusis" some years later. Heretofore nerve section for torticollis served both the afferent and efferent arc, whereas by Doctor Taylor's hemilaminectomy the afferent arc only was sectioned intradurally, namely the dorsal roots of the first four cervical nerves and the spinal portion of the spinal accessory nerve.

The patient was still very much improved when last heard from, fourteen years later, although not completely cured. In 1923 Harvey Cushing presented a patient before the meeting of the Society of Neurological Surgeons

in Boston upon whom he had sectioned intradurally the spinal accessory and the dorsal roots of the first four cervical nerves of the same side with great improvement of the torticollis. Doctor Cushing's patient complained of some hoarseness which probably was due to the fact that the spinal accessory nerve was sectioned at the formen lacerum. Thus after the nerve had received the accessory portion which is derived from the most caudal portion of the nucleus ambiguous which is referred to Edinger's nucleus and supplies the laryngeal musculature, it seems to me that if the spinal accessory is to be cut within the dura it should be cut just below the point at which is received the accessory portion and thus even a temporary paralysis of the laryngeal muscles would be avoided.

Doctor Stookey performed, in 1924, at the Neurological Institute, a hemilaminectomy and a dorsal-root section of the first four cervical nerves together with the spinal accessory upon a patient with spasmodic torticollis. While the patient was considerably improved he was not completely improved and he feels now that were he to repeat this procedure he would certainly do a bilateral dorsal-root section.

Doctor Foerster, of Breslau, has published a series of seven cases surgically treated in which he has done an intradural section of both the ventral and dorsal roots of the first four cervical nerves as well as the spinal accessory for relief of spastic torticollis.

The attempt to destroy the neural arc by sectioning the afferent system alone in so far as the cervical nerves are concerned is, it seems to the speaker, a decided step forward.

THE CURABILITY OF CANCER

Dr. John B. Deaver, of Philadelphia, read a paper with the above title for which see page 841.

Dr. Franz Torek, of New York, remarked that the question of curability arises every time we have to deal with a case of cancer and, except in cases of very slight malignancy, such as those on the forehead, cheek and the like, the prognosis will have to be guarded. It is difficult to predict what is going to happen, and this has led to the three- and five-year limits of safety; but whatever limits we place, they are perfectly arbitrary. All surgeons had had the experience that some cases show the first manifestations of recurrence later than five years after the operation—some very much later. Doctor Torek remembers one case of sarcoma of the liver which came under observation eleven years after a sarcoma of the eyeball had been removed. With this gloomy side to the picture, one does well to be guarded in prognosis. Fortunately, the cases one sees long after the five-year limits who are well, are much greater in number than the gloomy cases. What one must ask oneself is, are all these patients waiting for a later period in which recurrence is going to come? As long as one is unable to tell what the exact nature and causation of cancer are, the answer to this question will remain more or less uncertain. Those who believe it is a local manifestation of a constitutional disease

will be much more pessimistic than those who believe it is a local disease which later becomes constitutional.

While early surgery is always the important thing, in addition to that it must be as radical as is possible. In this connection the speaker said that a recurrence, meaning thereby a return of the disease after all vestiges of abnormal cell growth have been removed, in his opinion does not take place. A so-called recurrence is an evidence that the riotous cell growth originally present had not been completely removed but that there had remained behind some of the cell growth and had caused the recurrence, so-called. This is in no way a slur at surgery, because our senses are unable to recognize cancerous deposits of a microscopically small size, and in many cases one is unable to tell whether there is a distant metastasis present already. To cite a concrete case: a woman two years and nine months ago was operated upon for uterine cancer and a hysterectomy performed. There was no local recurrence. Last August she began to be unable to swallow solid food. X-ray showed a large tumor with a well-defined outline in the thorax, and the œsophagus was angulated by this tumor to such an extent as to be obstructed. Naturally, at first it was thought to be a metastasis from the uterine cancer, but the outline was so well-defined that both X-ray men and physicians thought it was a well-encapsulated tumor and made a diagnosis of mediastinal dermoid. She was operated upon three and one-half weeks ago and a carcinoma of the lung found. This was resected and the patient made an operative recovery. When did this metastasis take place? It may have been swept by the blood current to the thorax long before the first operation was done, but the speaker is certain that subsequent to a complete removal of the primary cancer it could not have been swept there. One must admit the possibility that it may have been forced into the circulation at the time of the operation by pressure on the diseased organ, and such a possibility is of importance because it throws light on the subject of the curability of cancer as far as it concerns the method of handling the cases. One can be sure that rough handling and forcible retraction of the tumor by a husky assistant could quite probably bring about metastasis. In dealing with malignant tumors it is important to handle them in a gentle way, not only at the time of operation but at the time of examining the patient. Metastasis from the uterus may be caused by the first examination of the patient, if the handling is very rough. It is perfectly well understood that it is necessary to plan and carry out an operation of this kind so that all diseased tissue will be removed, but not so well understood that at the time of removal these cancerous tissues must be handled gently. The surgeon who makes it a habit to handle them gently will have fewer metastases than the one who does not pay any regard to that.

Research into the chemistry of the body may lead to a solution as to the constitutional condition or the susceptibility of certain individuals. Traumatism or chronic irritation is to some extent responsible for the creation of certain cancers, but inasmuch as one knows that the very same kind of

traumatism which seems to produce cancer in some cases, fails to do so in a vast majority of other cases, one feels that there must be a susceptibility or predisposition which acts in certain instances to cause the irritation or trauma to produce the cancer.

WATER INTOXICATION

Dr. Alexander Randall, of Philadelphia, called attention to four or five physiological observations to see if any deductions could be drawn from these bearing upon the picture of water ingestion in urological surgery. Taking first a case of benign prostatic hypertrophy as the most uncomplicated picture (as likewise one in which urologists are accustomed to consider a high water intake to be of particular value), he spoke of the clinical picture not infrequently seen either pre-operatively, or post-operatively, in which the patient does not seem to be doing as well as expected, and yet in whom no particular group of symptoms points to complications in the pulmonary system, the circulatory system, or the renal system. This picture is one in which a little lassitude or asthenia suggests that the patient is not at his best—that there may be slight headache, perhaps abdominal distention, hiccough, nausea or even vomiting. This picture does not necessarily have to be in the immediate post-operative period. Carrying this in mind, he asked the audience to correlate with it the following physiological observations that have been scattered in the literature now to be correlated under a possible syndrome, showing that these patients perhaps are suffering from water intoxication.

The subject of water intoxication in man was first presented by Rowntree in 1923, who stated that symptoms of poisoning and the mode of death in higher animals had never been determined. Satiety has been man's safeguard; gastric distress, regurgitation and vomiting protecting him from too great an ingress of fluid. In lower animals it has long been recognized that the salt water mollusk placed in fresh water dies: that the fresh water amœba placed in distilled water likewise dies, and this has been supposed to be due to the diffusion of salts from osmosis. Loeb showed that such an amœba would remain alive if sodium chloride as diluted as 8 to 100,000 be placed in the distilled water.

In Rowntree's animal experimentations he showed that intoxication followed a very definite syndrome of symptoms. Experimental dogs would show asthenia, restlessness, urinary frequency, diarrhœa, nausea, retching, vomiting, tremor, ataxia, coma and death. In man the following train of symptoms occurs: increased blood-pressure, headache, dizziness, restlessness, chills, fullness of the abdomen, vomiting, dyspnœa and peripheral muscle cramps.

Doctor Randall stated that several members of his staff had tested this intoxication by drinking between three and four litres of water in an hour and that uniformly, each one developed asthenia, headache, and dizziness; the intake being no further pushed in this personal experimentation.

The second physiological observation which Doctor Randall brought forward was the statement made by Crile, that if fluid is pushed to an excess the body protects itself by eliminating it into the stomach from whence regurgitation and vomiting rid the system of such excessive fluid intake.

The third physiological observation to which he drew attention was one recorded by Richards in his studies on renal function. Richards has shown that the glomerular filtrate while passing through the tubules is subjected to a marked reabsorption of both water and certain solids. His experiments showed that glomerular fluid contained higher estimations of chlorides than pelvic urine, and that therefore chloride was one of the products which was normally reabsorbed by the tubule cells. Further experiments demonstrated that the amount of reabsorption of chloride depended to a certain degree upon the length of time that the fluid remained in contact with tubule cells, and that when a marked diuresis was produced there was a greater concentration of chloride in the urine apparently due to the fact that the rapidity of secretion failed to give tubular reabsorption sufficient time to be completed. Therefore, under such marked diureses, the experimental animal lost salts over and above what would normally be eliminated.

Fourthly, Doctor Randall called attention to Edsall's disease, or salt starvation, first described by Edsall, and explained by him to be due to excessive diuresis. Edsall pointed out that men subjected to high temperatures and profuse perspiration, no matter what their occupation, would be found to be imbibing fluids of high salt content, pointing to the heavy beer drinking of the steel mill workers, who often put table salt in their beer; as also the oatmeal water used by harvest hands and football players. Edsall's conclusions were that the symptoms described by him were produced by salt starvation through diuresis and one can now see how closely it is allied with the picture of water intoxication.

Finally, the speaker presented an observation recorded by Austin, Stillman and van Slyke in their studies on urea excretion. These investigators attempted to produce in themselves a high diuresis. On tap water they were able to reach a rate of elimination of eleven litres per diem. This produced great water disgust and could be maintained with difficulty. They found that if they took one-half strength normal salt solution instead of ordinary tap water, that they could drink a great deal larger quantity per diem, that disgust for water was not so marked, and that a diuresis as high as nineteen litres per diem was obtained.

Correlating these various observations with clinical experience and the picture of the prostatic as above cited, Doctor Randall stated that he felt that we possibly overdid the question of water administration in some of these patients whose clinical condition did not appear satisfactory, and in whom no particular complication was demonstrable. Likewise, he stated, that to offset the possible occurrence of water intoxication, he was now having all patients on his service who were on a forced fluid intake given water in which has been dissolved a tablet representing a third strength of Ringer's solution.

They have noted that the patients do not object to such, and Ringer's solution was chosen as it incorporated the other valuable body salts, rather than to use plain salt solution, which might represent but one chemical factor in the picture.

Dr. Edwin Beer, of New York City, said that the recognition of symptoms of water intoxication is very difficult. The tendency to base it upon aminal experimentation, as developed by Rowntree's work, is of questionable accuracy. Robert Koch over twenty years ago, while being shown about a New York hospital, saw the water faucets in the various corridors and asked what they were for. He had never seen them in Germany. When the attending physician told him "distilled water for drinking," he said: "Why are you poisoning your staff? Don't you know that distilled water is injurious to the body, not only to the mucous membrane of the mouth but to the œsophagus, the stomach, and wherever it touches?" Much of the earlier animal experimentation was with water distilled in copper and many of the results were invalidated by the fact that damage was caused by the copper in the water. In other cases osmosis was disturbed by the fact that distilled water was not isotonic to the tissues of microscopic animals. When it comes to the higher animals, as well as the lower, a definite set of symptoms develops, such as Rowntree has called attention to: lassitude, dizziness, and if fed on water in large enough quantities a series of symptoms simulating strychnine poisoning will develop. These are all controllable by hypertonic saline solution.

In the treatment of prostatic patients, Doctor Randall has encountered some of these symptoms due, he believes, to an excessive introduction of water. Water per os undoubtedly leads to a train of symptoms difficult to explain! But water subcutaneously and by rectum rarely produces any such syndrome. In Doctor Beer's experience the only prostatic or renal patients who have showed marked disturbance of water metabolism were those who had a high degree of insufficiency; in these it may rarely, or better very rarely, produce such a syndrome that one thinks the patient is going into uræmia. On the other hand, the benefits of water (especially with glucose) by rectum or subcutaneously are so great that one must not be estopped from using it in large quantities. It not only stimulates diuresis but dilutes all poisons. It is well known that crystalloid poisons in great dilution may be introduced without in any way incommoding the body. Although one must be on the lookout for the indications of excess in the use of water by mouth, as well as for the discomfort from ingestion of water, one should bear in mind on the other hand that there is nothing like water, preferably with saline or glucose, to control the intoxication induced by the disease for which the patient is being treated.

BRIEF COMMUNICATIONS

THE OPERATIVE TREATMENT FOR INJURED CARTILAGES OF THE KNEE-JOINT

AT VARIOUS clinics in this country and on the Continent I have been struck with the great variation in the technic for the removal of semilunar cartilages from the knee-joints. On the Second Surgical (Cornell) Division at Bellevue Hospital and the Third Orthopedic Division at the Hospital for the Ruptured and Crippled we have, for the past few years, been using a technic for the operation which we believe to have certain definite advantages. The technic has been developed with the aid of Dr. Toufick Nicola. The accompanying drawings and pictures are inserted to clarify the special points of operation.

Technic.—The patient is placed on the operating table in a modified Trendelenberg position with the knees flexed to ninety degrees over the end of the table. The operation is always done under a tourniquet. The extremity to be operated upon is draped in such a manner that free motion of the knee is possible in all directions. The surgeon stands at the end of the table facing the flexed knee. An assistant stands on each side of the knee. One assistant retracts the edges of the wound, the other assistant catches the patient's foot with one hand and the patient's thigh above the knee with the other hand, thus being able to rotate the tibia or widen the joint, which materially aids in the removal of the cartilage.

The joint is opened by definitely identifying three layers as follows: (*a*) The skin incision is made parallel to, and slightly more than a finger's breadth from, the inferio-medial border of the patella. This incision is usually between two and three inches in length (see Plate 1, Fig. A) and about one-third of it is over the tibia and two-thirds of it over the internal condyle of the femur. Beneath the skin there is a fatty layer. Running on top of the capsule there are usually two or three small blood-vessels which may be divided and ligated. (*b*) The capsule is then cut through (see Plate 1, Fig. B) and the synovia is exposed. Running across the synovia there are two or three small blood-vessels which may be ligated and divided. (*c*) Synovia is then caught at two points with mouse-tooth forceps (see Plate 1, Fig. C) and opened with knife, extension being made with scissors. A culture at this point is taken. Retractors are put in place and inspection of the joint made.

If it is found necessary to expose the entire joint the upper end of the incision follows around, and parallel to, the superio-medial border of the patella and then along the edge of the quadriceps tendon. The patella is then displaced laterally and the joint exposed as in Plate 2. The incision is thus converted into an inside Murphy,[1] Fisher,[2] Moorhead[3]—the incision

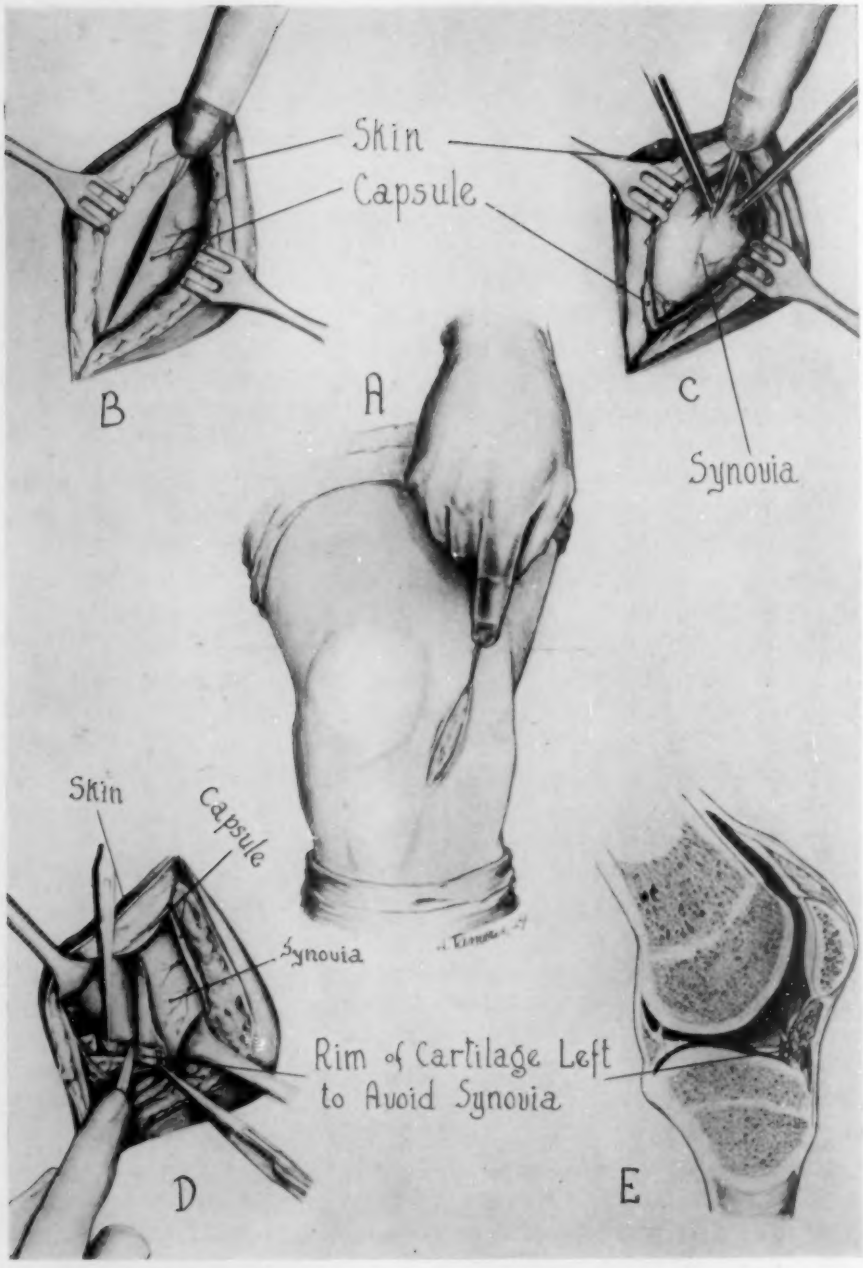


PLATE 1.—(A) Skin incision. (B) Skin and fatty layer retracted, capsule cut. (C) Synovia being opened. (D) Cartilage divided transversely and medial portion being excised, slight rim of cartilage being left so as to avoid vascular synovia. Anterior end of cartilage will next be excised. (E) Sagittal view of knee, line of excision of cartilage indicated.

going by all these names. An actual case where such an extension was necessary is shown in Plate 2. In this case it was necessary to remove (see Plate 3) a growth of cartilage on the inner condyle of the femur, a loose body in the joint, and a fractured semilunar cartilage. When the wound was closed no structure about the knee had been weakened. As an after-result a strong knee with full range of motion was observed one year later.

If only the cartilage needs to be removed it is divided transversely in line

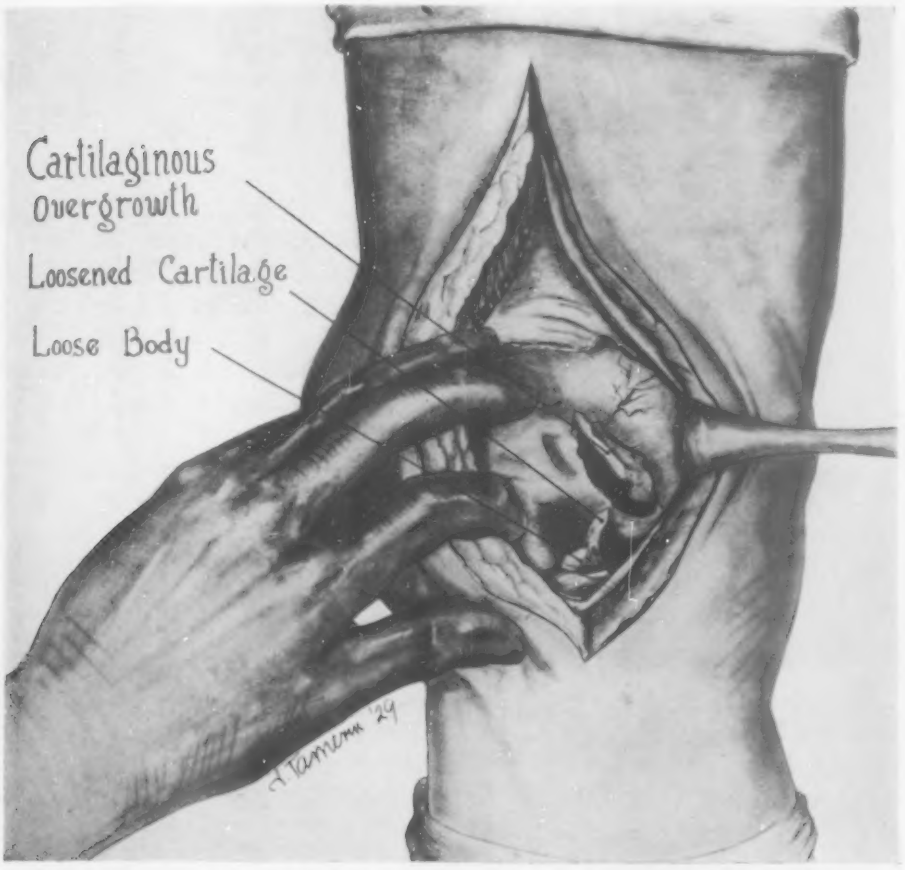


PLATE 2.—R. L., age thirty. A case requiring extension of incision parallel to patella and quadriceps tendon; patella retracted laterally, pathology noted, removed and shown in Plate 3.

with the original incision. This leaves two ends to remove. The synovia blends with the cartilage. The synovia is very vascular. The cartilage is avascular. Therefore in removing the cartilage grasp a cut end with a Kocher clamp and excise, but leave a tiny rim of cartilage remaining at its attachment to the synovia (see Plate 1, Figs. D and E). If the entire cartilage with rim is removed a denuded bleeding synovia is left, there is more or less hæmorrhage into the joint, and the same area will heal more slowly. At the point where the cartilage is torn from its synovial attachment there will be, of course, a gap in the line of excision.

After the cartilage is removed the patient is taken out of the Trendelenberg position and the foot of the table raised so that the extremity is in complete extension. This releases tension on the knee and makes the closure of the wound much easier.

The wound is then closed in three layers: First the synovia with a running number one chromic catgut suture, second the capsule with a similar suture, and third the skin with continuous medium black silk. Some surgeons argue that the capsule should be imbricated. We can see no advantage in this. All it does is decrease the circumference of the capsule of the knee and thus limit flexion of the knee.

After closure the knee is dressed and wrapped with sheet wadding and bandaged from the ankle to the groin. The bandaging is reinforced with adhesive strapping. If the whole knee-joint has been exposed by the extension incision we sometimes put a plaster-of-Paris moulded splint behind the knee.

PLATE 3.—Specimens removed in case shown in Plate 2. (1) Overgrowth of cartilage on femur; (2) loose body; (3) bucket handle cartilage.

After Care.—The patient is taken to his bed and the extremity is elevated on two soft pillows. Morphine is usually necessary, one quarter grain, repeated sometimes the first night, after that it is rarely necessary.

We are then in no hurry to start early motion, and we can see no advantage or reason for it. We let the patient begin to feel like flexing his knee before we encourage him to do so. This is usually about five to seven days. We start him walking about the eighth or ninth day. This does not mean he cannot start motion or walk much sooner. We used to urge the patient to walk within two to five days after operation, and though we rarely had any ill effects we believe that œdema, swelling and fluid in the joint are reduced to a minimum by keeping the patient quiet for a few more days in bed.

We advise physical therapy treatments and find it is usually from five to eight weeks before we have a symptom-free normal knee.

The same technic is carried out for external cartilages, the incision being made at corresponding points on the lateral side of the knee.

Discussion.—We wish to emphasize especially the following points:

1. In making the approach to the cartilage three definite layers about the knee must be identified and separately handled, namely, the skin, the capsule and the synovia. These structures should be approximated separately at the close of the operation.

2. The direction of the incision is in line with the distribution of the sensory nerve fibers to the skin of the knee. Hence few fibers are divided and areas of numbness seldom result. With other incisions we used to have many post-operative complaints of numbness of an area of skin.

3. By leaving a fraction or rim of cartilage the synovia remains intact, there is no post-operative bleeding and there is no delay in healing. Leaving this rim is a point I have not seen mentioned in the literature.

4. The incision is placed so that if complete exposure of the knee-joint is found necessary an extension is in direct line with what is being more and more considered the proper approach to the knee-joint, as contrasted with the old method of splitting the patella, cutting straight across the capsule and tendons of the joint and other such incisions.

5. We can see no reason for insisting on early motion and walking during the first ten days of convalescence.

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The course is under the direction of Dr. Joseph F. McCarthy.
The class is limited to ten.

For descriptive booklet and further information, address

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